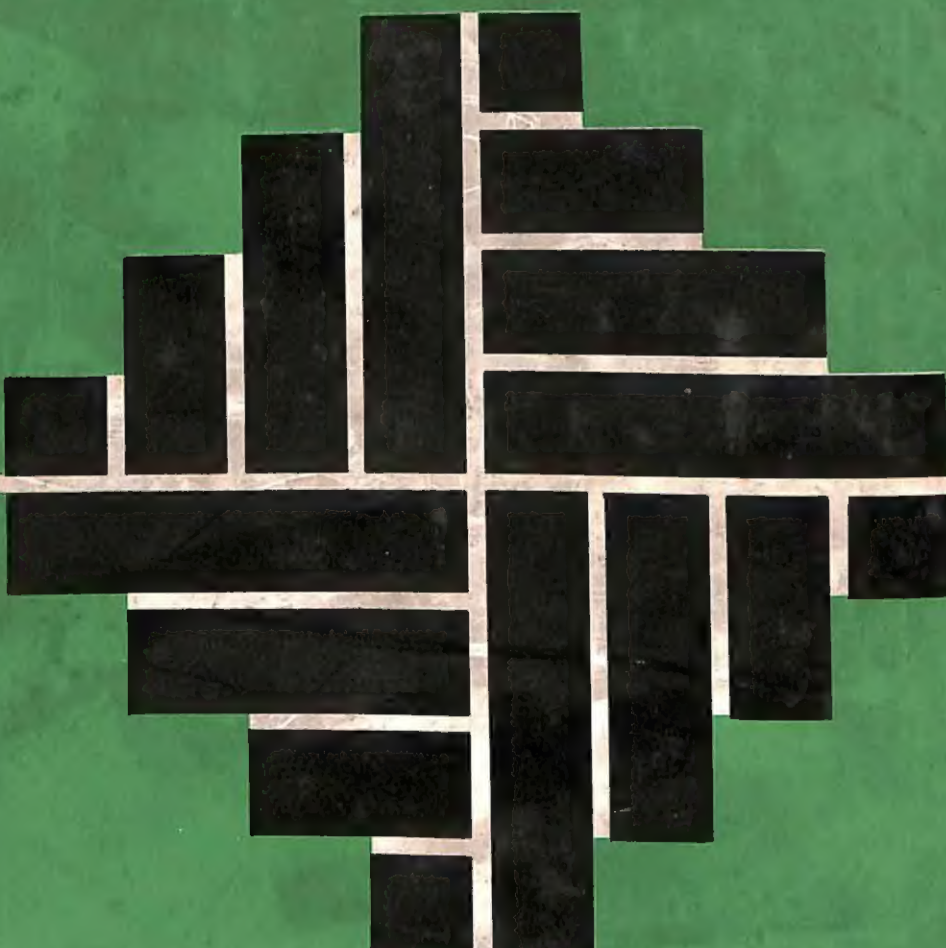
RURAL ECOLOGY



C MUMTAMAYEE

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C. MUMTAMAYEE

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TO

BRIJ RAJ SARAN COWSHISH

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C. Mumtamayee

PREFACE

The theme of the study is human ecology. It is a branch of ecology which studies relationships between organism and his environment. It is a comparatively young branch of knowledge. There have not been many studies on the concept of human ecology within the framework of ecology.

The term 'ecology' was coined by Ernst Haeckel[1] in 1869. He defined ecology as the total relations of the animals to both its organic and its inorganic environment. It was generally felt that this definition leaves out little what is not ecology.

Since Haeckel, many authors have defined ecology in various ways. They all are unanimous in the opinion that ecology deals with the interactions between organism (or organisms) and his (or their) environment. Early authors emphasised on the structure of the relationships while the later authors showed greater concern for the functioning of these relationships. In the middle of this century, it was realised that both the structure and the functioning of the relationships are important in the understanding of ecology.

The first comprehensive definition of ecology was given by Eugene Odum[2] in 1962. He defines ecology as 'the study of structure and function of eco-systems.'

Apparently eco-system is the fundamental unit of study in ecology. The term was coined by A G. Tansley[3] in 1939 to express the sum total of organisms and their physical habitat.

A more generalised definition of ecology was given by Margalef[4] in 1968. He defines ecology as "the study of systems at

1. Haeckel, E., (1868), Quoted by A. Hawley in *Human Ecology*, 1960.
2. Odum, E.P., (1962). *Fundamentals of Ecology*, Philadelphia, Saunders.
3. Transley, A.G., (1939), *The British Islands and Their Vegetation*, London, Cambridge University Press.
4. Margalef, R., (1968), *Perspectives in Ecological Theory*, Chicago, University of Chicago Press.

a level in which individuals or whole organism may be considered elements of interaction, either among themselves, or with a loosely organised environmental matrix." He adds further that systems at this level are named eco-system and ecology of course is the study of eco-systems. To understand his definition, it is necessary to know what a system is.

Chorley (1968)[5] defines a system as 'a set of objects together with relationships between the objects and their attributes'. This is further corroborated by Harvey[6] who points out that a system has three components : (*a*) a set of elements identified with some variable attributes of objects ; (*b*) a set of relationships between attributes of objects ; and (*c*) a set of relationships between those attributes of objects and environment, (p. 451).

Thus, ecology is the study of a particular type of system, called eco-system whereas human ecology is the study of an eco-system where at least one of the component is man. The components have functional links provided by some form of energy processed by man and form sub-systems within the high order system of an eco-system. It is customary to name the eco-system after the locational framew ork, *i.e.*, static habitat of the environment such as 'Khadar Eco-system' of the Khadar environment.

It may be pointed out that the human ecology has been described in great details by Mekenzie[7] (1959) and Amos Hawley[8] (1960), but their definition is one of the partial definitions before Odum synthesised the various aspects of ecology. It is restricted to sociological point of view and is not broad enough to include other sciences, such as geography The definition of human ecology given above is broad enough to provide paradigm to all subjects including geography.

All branches of ecology have hierarchical organisation based on the level of study of the organism in question. Generally, four

5. Chorley, R.J., and Haggett, P. (eds.), (1968), Socio Economic Models in Geography, London, Mathuen.
6. Harvey, D., (1969), *Explanation in Geography*, London, Arnold.
7. Mckenzie, (1959), "Ecology, Humun", *Encyclopedia of the Social Sciences*, V, 314.
8. Hawley, A.H., (1960), *Human Ecology : A Theory of Community Structure*, New York, Ronald Press Co.

levels are recognised, organismic or individual, population, community and eco-system level. Organismic level concentrates on individuals, population level on aggregates of undifferentiated individuals and community level on the differentiated populations. Eco-system level is the highest level. Though each level is an aggregate of a lower level of organisation, it also has some attributes exclusive to it alone. Apparently, a higher level study is not possible without a lower level study. However, geography is concerned with the aggregates and the higher levels as spatial patterns and processes have clear expression by way of a group rather than as individual's actions (Klausner).[9]

Any branch of ecology can be approached by using (*a*) eco-system approach, (*b*) habitat approach. The study of ecology in the field adopts habitat approach. It makes all possible measurement for all the required variables of organisms and their environment. It also determines the exact relationship between the organisms and their environment. Once the exact relationships have been developed, one proceeds to eco-system approach organising the study of the organisms at individual, population, community and eco-system levels. Accordingly, one determines the structure of relationship. It connects a lower set of organisms and their interrelations and interrelated environment to a higher level. Each level is called a trophic level. Thus, while habitat approach deals with structure and function of relationships at one trophic level, eco-system approach connects one trophic level to another. In terms of the systems analysis, sub-systems are studied inductively as independent systems in the field using habitat approach while eco-system approach is used later to link sub-systems deductively. Apparently, initial study in ecology would use habitat approach and once all the components of environment are fully understood, they are inter-connected using the eco-system approach. The study uses habitat approach starting with the population level, building up the Khadar-eco-system at the end.

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9. Klausner, S.Z., (1971), *On Man in His Environment*, San Francisco, Jossey-Bass, Inc.

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1
The Introduction

1. THE DISTRICT

The rural ecology of the Khadar tracts studies a human eco-system confined in Meerut district. It is located at the western margin of Uttar Pradesh. The State of Haryana with Rohtak district and Delhi form the western margin of the study area (Figure 1.1). Barely 200 kilometres north are the Siwalik foot slopes of Saharanpur with intervening district of Mazzafarnagar as the northern margin of the study area. Bijnore and Moradabad in the east and Bulandshahr in the south, both in Uttar Pradesh, are the other bounding districts of Meerut. The study area comprises of the tehsils of Baghpat, Sardhana, Meerut, Mawana, Ghaziabad and Hapur.[1]

The district has well identifiable boundaries in the east with the river Ganga and in the west with the river Yamuna (Figure 1.1). The Ganga and its main tributary, the Yamuna, are the perennial rivers originating from the glaciated Himalayas. Flowing roughly along the eastern boundary of Baghpat is the Hindan. Originating from the Siwalik foot hills, it is one of the minor tributaries of the Yamuna and is the third perennial river of Meerut district. The three perennial rivers form the flood plains as three Khadar tracts which collectively form the study areas of this study.

2. THE STUDY AREA

As seen in Figure 1.1, the Khadar tracts of the study area form elongated strips at eastern and western margins of Meerut

1. Recently Ghaziabad and Hapur have been separated to form Ghaziabad a district.

district with Hindan strip in the western-central position. The eastern Khadar strip of the Ganga is linked to the district headquarters of Meerut through highways of Bijnore in the north of Parikshatgarh in the centre; and of Shahjahanpur-Garhmukteshwar in the south. Parikshatgarh highway provides the shortest linear distance between Khadar and the district headquarters, linking such villages as Kishoripur and Mamipur (Code numbers G-069 and G-064 in Figure 1.1).[2] Meerut-Bijnore highway has a diversion through Mawana entering the Khadar strip at Hastinapur. This road runs through the villages of the study area running north from Latifpur (Code number G-046 in Figure 1.1 and Appendix A). The diversion is not marked on the map to avoid ambiguity with the village boundaries. Garh highway through Shahjahanpur provides the longest distance between the Ganga strip and Meerut. Garhmukteshwar is located on National Highway, NH-24, linked to Delhi *via* Hapur, Pilkhuwa and Ghaziabad with broadgauge running parallel to it apart from a road to Bulandshahr in the south, SH-18.

The Yamuna Khadar in the west is linked to Meerut at Baghpat in the centre (Figure 1.1). Delhi-Saharanpur national highway, NH-57, runs north of Delhi border through or along the Khadar with its node at Baghpat. Running parallel to it is the narrow guage railway line. The northern Yamuna Khadar is connected to Tanda (Code number Y-001, Appendix A) at the terminus in the north-west and Baraut in the east moving further to Sardhana to join Meerut-Muzaffarnagar road, NH-45, and the railway line highways. The Hindan Khadar in its southern extremity is criss-crossed by highways from Delhi running north, NH-57 and NH-45, and east, NH-24, with additional Meerut-Baghpat road in the north and Surana (Code number H-039)-Muradnagar road in the centre and State highway-22 to Bulandshar in the south. Smaller roads link the Hindan Khadar to urban areas of Aminnagar Sarai and Khekra towns of Baghpat, Rasulpur Dhulari town of Meerut and Modinagar of Hapur.

Thus, the three Khadar tracts form peripheries of a large network of a circulation system centred at Meerut and Ghaziabad

2. Appendix A for village names and their code numbers.

with a still larger node at Delhi. Each Khadar, *i.e.*, Mawana-Bijnore road (Figure 6.2). There are other roads that run from Mawana entering the Ganga Khadar at Mukhdumpur (G-062), Kishoripur (G-069) and at Abdullapur (G-128) terminating in the valley flat of the Ganga.

The Ferries and Boats. provide link in the circulation lines interrupted by some obstacles, *viz.*, wet or inundated area. Boats keep to riffles of a channel (Chapter II) to avoid the risk of running a, round in shallow water and making use of the natural transport of energy. Ferries ply in deeper water. The points connected by ferries or boats result in inter-actions of man located on the two sides of the channel. Boats ply in the areas of less frequent interactions than in the case of ferries. Boats, therefore, can be seasonal or have less frequent service while ferries have more regular service. Small boats are used for relief and rescue of man marooned in the inundated areas of the valley flat subsystem. On the other hand, ferry service may be abandoned when water level increases in channel. The areas having boat and ferry service change with each dislocation in meander loops. There are few ferries across the Ganga as the channel has shallow areas of bar deposits or islands in the various meander loops. One such ferry point is shown east of Khanpur Garhi (G-087) across the Ganga in Figure 6.1. There are many such points along the Yamuna and the Hindan through the Hindan-cut just north of Ghaziabad town. The channel nearly dries out south of the town and joins the Yamuna south of Ghaziabad tehsil. These Khadar tracts provide a fixed locational framework, also called static habitat, as a home for man in the Khadar eco-system.

The study area of the district forms the western margin of the Ganga drainage system flowing over the northern plains of India. The Sutlej-Indus water divide lies to the west of Meerut district. General elevation of the district is between 200 to 300 metres. It has a primary north-south slope along the Ganga and a secondary west-east slope towards the river.

The uniformity of slope is interrupted by small local basins and upwarded areas. The largest structural basin lies in the south-western part of the district covering the interfluve of the

Yamuna and the dried Hindan. A major area of upwarping[3] occurs at the central part of the Ganga Khadar (Figure 2.5). The channel runs north-south till the axis of upwarping blocks its way forcing it to curve slightly eastwards. The upwarpings have caused escarpments in this part of the Ganga drianage system. These escarpments are generally called Khola/Kholi. A channel develops braids (Figure 2.5) while negotiating the upwarping retaining its meander form otherwise. A parallel axis of upwarping is located further north which causes entrenchment of the Hindan north of its confluence with the Kali nadi resulting in the absence of a Khadar. It extends westwards across the Yamuna with braids north of Baghpat.

The Khadar tracts form a distinct identity containing a Khadar environment within the district. The environment has loosely integrated variable attributes. Some of the variables are considered to be closely integrated as a Khadar eco-system. The attributes of the eco-systems are outlined below.

(*a*) There is the new flood plain along the channels marked by present or potential inundation associated with channel flow, covering the field of fluvial action along with the field of mass wasting. It contains a valley flat with active and abandoned parts of channels. It is formed as a result of bank overflows at the time of above average channel discharge (Figure 2.2) where river gradient is less than 1° and local relief along the active channel is less than 10 metres. The slope along the Hindan north of the study area is more than 1° and local relief is of generally 30 metre where water level rises in the channel at the time of high discharge without causing the bank over flows, hence no flood plain and Khadar tract. Similarly the Kali Nadi between the Ganga and the Hindan is a perennial river with gradient of 2° to 3° and acts only as a natural drain without a flood plain. A flood plain with valley flat merges with area of mass wasting. It is an inorganic attribute of the environment and forms a Khadar habitat marked by wet and dry niches.

(*b*) The periodic inundation from bank overflows keep the surrounding areas moist at the wet niches supporting hydro or

3. Based on interpretion of the topo sheet no. 53 L/1

hygrophytes, largely belonging to family of grasses. The drier niches may support the higher life forms, *viz.*, trees, though such areas are limited. The dominance of grasses, herbs and forbs are associated with grazing cattle. Most of them are domesticated to obtain milk and to be used as beasts of burden. Grasses and higher life form is cleared in favour of the cultivated plants. The plants and animals together form the Khadar biomass.

(*c*) Man is dispersed in the flood plain aggregating at the drier niches and avoiding wet or partially wet areas. As a result, he forms population clumps above the escarpments at Bangar edge. Small clumps appear at comparatively less drier niches of a valley flat. Population in clumps changes with births, deaths and migration patterns. The patterns adjust to the physical attributes of a flood plain, *viz.*, meanders of a channel sweeping down stream. The changes are rapid and more distinct along an active channel than away from it. These attributes of the environment are collectively organised as man at the population level.

(*d*) The individuals in a clump are differentiated among themselves by the nature of work they perform, relating them to the Khadar environment. Man thus differentiated forms the populations where each population is an aggregate of individuals with similar attributes. Population interacting with local resources alone dominate a flood-plain where man is dominantly a food raising class at the valley flat. The populations interacting with the wider resources base dominate at the edge of Khadar habitat. The interactions among dissimilar populations organise man at the community level.

(*e*) Man along with his belongings locates himself in the dwellings at the Bangar edge and at the dry spatial segments of a valley flat. He interlinks dwellings with the circulation system converging to the Bangar edge in general and the urban centres in particular. These attributes collectively form a settlement system of the Khadar environment. It is not only the end product or surface expression of man in the Khadar eco-system but also the embodiment of human energy that circulates in the eco-system of man in the Khadar environment.

Thus, Khadar tract is a piece of land with distinct habitat, biomass, population clumps, community and settlement systems as interacting elements. These are the chosen variables of the high order system acting as the Khadar eco-system.

3. THE DEMARCATION

A Khadar tract with the above attributes can be demarcated spatially on the basis of physical and functional criteria.

The physical demarcation of the Khadar tract is based on the inorganic attributes of the Khadar habitat. It covers a valley flat along a channel with its banks in the Bangar edge. A channel itself is excluded as it forms part of a fresh water environment. A valley flat is an inundation prone area but the valley banks are generally dry and dissected by gullies forming bad lands. Banks extend upto the gully heads so that a Khadar tract has the physical location between an active channel on one side and the gully heads of the badland topography on the edge of the Bangar on the other side. It is the inundation prone area of a valley flat along with the area directly feeding to the extention of inundation prone area at the Bangar edge. Such a demarcation of the Khadar corresponds with the colloquial meaning of the word Khadar.

Man interacting with the Khadar environment is not confined to the physical limits of the Khadar tracts. Very often, he is located at the margin of the adjoining environment *i.e.*, the Bangar. This area holds a transition from one environment to another forming the *ecotone*. The Khadar eco-system operates with man in the ecotone. Assuming the limited resources of an individual, the interactions may be considered to be confined largely to his village area so that the functional demarcation of the Khadar tract extends beyond the physical demarcation to include territories of the villages partly in the Khadar and partly in the Bangar environments. Some villages may be located in the Bangar in the immediate contact with the Khadar environment but with no territorial extension into the latter. It denotes absence of the ecotone and such Bangar villages are excluded from the functional demarcation.

The towns and urban areas located along the channels are excluded from the study area even if they have territorial extension into the physical limits of the Khadar. An urban area is set off from the flood plain through a protective wall, embankments or the stretch of undeveloped areas. Thus the administrative area of a town may cover a part of the Khadar tract but man located in an urban centre interacts with the urban environment which is dissimilar from the Khadar that is essentially rural. These urban centres are Baghpat along the Yamuna, Rasulpur, Dhulari and Ghaziabad along the Hindan and Hastinapur and Garhmukteshwar (Garh) along the Ganga (Figure 1.1).

The scope of the study covers the Khadar environment located over the non-urban, rural environment within the functional demarcation of the Khadar tracts. It studies the elements of interaction and the nature of interaction of man and his Khadar environment forming the human eco-system. It excludes man at the individual level of organisation as he is barely different from his brethern Bangar man. His identity as Khadar-Man is established only at the higher levels *viz.*, at population, community or eco-system level (Klaunsner).[4]

4. THE FACTS AND FIGURES

The facts and figures for the required work are collected through primary and secondary sources. The land use data is collected at village level from 'Milan Khasra' 1974-75.[5] Agricultural data is collected from the 'Chittha Rabi'[5] and 'Chittha Kharif'[5] of the same year. Population data is obtained from District Census Handbook, Meerut district of 1951, 1961 and 1971.[6] Some land use data for 1971 is obtained from village and Town Directory, Meerut district, 1971.[6] The Indian Daily Weather Report is consulted for climatic data. Handbook of Irrigation in India[7] is consulted for some properties of the rivers. Soils of India (Ray Chaudhuri, 1966)[8] and The Upper Ganga

4. Klausner, *ibid.*
5. Collected from the Revenue Department of the Tehsil Headquarters.
6. The Census of India.
7. Census of India, 1971, Handbook of Irrigation in India, Delhi.
8. Ray Chaudhari, 1960, *Soils of India*, New Delhi, ICAR, No. 25.

Khadar an Interim Report (1973)[9] is used to collect information about soil profiles.

The facts and figures are very largely supplemented by first hand information through field work. General information about the area is collected through field work. Detailed information about the household demographic and economic structure is collected exclusively in this way. Many conclusions regarding the habitat and the biomass are based largely on field observations.

A village or revenue *mauza*, is the primary areal unit of study. There are 268 villages covering the three Khadar tracts. In some cases the observations are made at this level and later generalised for the Khadar environment of the district. Sometimes a priori hypothesis is raised about some relationships and the particular observations are used only to test the hypothesis.

5. THE METHOD AND METHODOLOGY

The method of the present study follows a few steps. At the initial stages the concept of ecology was studied in order to draw an outline of the concept of human ecology. At the same time river and river valleys in general and Meerut district in particular were studied through the available published or unpublished literature. A working hypothesis of the Khadar eco-system was framed. The study area was demarcated and secondary data collected on the basis of the operational hypothesis. The data was tabulated and analysed. The operational hypothesis was adjusted or modified where necessary in the process of working through the Chapters.

An intensive field work was done with the revised operational hypothesis. Each village was treated as a sub-habitat with the general Khadar environment for the empirical study. A small cluster of villages was chosen from the different areas which appeared of a particular type on the maps prepared earlier. Thus, clusters of villages from the northern, central and southern parts of each Khadar were chosen for field work covering 40 per cent of all the villages in the study area. In all, hundred villages were

9. NAO, 1965, *The Upper Ganga Khadar, An Interim Report*, Calcutta.

visited and seventy villages were surveyed, which include forty uninhabited villages and thirty inhabited villages. Significantly, many villages were found to be uninhabited during the field work though were populated during the census count of 1971. Apparently the shift from inhabited to uninhabited villages can occur within two census years. The sections of the Ganga Khadar used for sample study are shown in Figs. 2.4, 2.5 and 2.6.

About 75 per cent of the inhabited villages that were surveyed are located over the valley flats which cover 90 per cent of the Ganga Khadar and 10 per cent of the Yamuna Khadar. There is no populated or unpopulated village located in the valley flat of of the Hindan. The percentage of villages surveyed on the valley flat to the total number of villages on the valley flat is about 60 per cent for the Ganga and the Yamuna Khadar separately.

The empirical conclusions based on the individual villages are synthesised and compared with the operational hypothesis and the conclusions are generalised. The generalisations are presented in the study in a theoretical form. The specific cases from the three Khadar tracts are presented in the study only in support of an argument or as evidence of a logical argument. The theoretical presentation is crude as there are many gaps in the information resulting from the limited resources of an individual researcher. The epitome of the thesis is the model of spatial self-sufficiency given in Chapter V that proposes modalities for making an area self-sufficient in terms of want satisfaction.

6. THE PERIOD OF FIELD WORK

The period of field work bears some significance for the contents of the present work. Major field work was done from October 1976 to March 1977. The work began when people in their dirty rags cleared sugarcane fields while trees at the ecotone and Khadar stood bare with their gnarled trunks. The field work lasted till the villagers got themselves new pairs of clothes after the sale of their sugarcane (a cash crop) and mango, luquat and other trees started blossoming at the Bangar edge.

The period of the field study coincided with the emergency days. Forced family planning drive was on and people were very

hesitant and reluctant in giving the demographic details of their families. The muslim villages and the villages close to the towns did not give any information at all. This was also the time of land distribution to the landless. As a result, the economic structure of a family was often distorted or not answered by the households. The households and villages, from where reliable information could not be obtained, were deleted from the tabulations.

7. THE ORGANISATION

The study is organised in seven Chapters giving brief exposition of the Khadar eco-system located in the Khadar tracts of Meerut. The First Chapter introduces the area and its contents. The Second Chapter is the Khadar habitat giving the inorganic attributes of Khadar environment which forms an element in man's interactions. The Third Chapter introduces organic elements as Khadar Biomass. The Fourth Chapter introduces man as undifferentiated aggregate forming population clumps and is called Man at Population Level in the Khadar Environment. The Fifth Chapter organises man into differentiated groups as Man at Community Level of Organisation. The Sixth Chapter deals with the settlements and the lines of circulation as the Settlement System. The Seventh Chapter finally concludes the other Chapters and links them together in the form of an integrated Khadar eco-system under the heading of the Summary and Conclusions.

2

The Khadar Habitat

1. THE INTRODUCTION

The Khadar environment to be studied in this study has various interacting variables to form the Khadar eco-system. According to Odum[1] the inorganic variable is called the habitat.[2] The habitat has dual function in the eco-system. On the one hand, it is static providing a fixed location or home to the other variables of the eco-system (Chapter 1). On the other hand, the habitat, as a dynamic variable, is an element of interaction in the Khadar eco-system. This chapter studies the Khadar habitat as a variable in the Khadar eco-system.

The dynamics of the habitat operate over the parameters of the habitat which provide a physical base for energy circulation manifest in the form of the operative processes. These are geomorphic processes of the fluvial action and mass wasting along with the biotic processes connected with organisms. Fluctuations in the energy input through the parameters run through the processes constantly changing the resulting output in the form of the habitat series. Output in the steady state appears as the medium series though it can stretch as the extended series or become demunative as the truncated series. The medium series has a normal Khadar landform consisting of the habitat zones, *e.g.*, a valley flat next to channel, rising wet and dry reception zone, rugged Khola zone and the Bangar edge located between the

1. Odum, *ibid.*
2. In this study the term habitat is used in the sense of Odum's definition.

Bangar on one side and the Khadar environment on the other side. Some zones are missing in the truncted series so that the Bangar edge descends abruptly to the channel below. The extended series has more than one valley flat. Any further variation in the input of energy can form the additional habitat series.

2. THE PARAMETERS OF THE KHADAR HABITAT

The parameters of the Khadar habitat are set by energy circulation shaping the Khadar landform. Energy circulates within the format provided by the lithological structure and diastrophism at some initial point of time.

The lithological structure is the basic frame of reference in the parameters of the habitat. The structure is a part of the Gangetic trough filled with alluvium. It is massive and structureless. The Gangetic trough covered by the habitat of the study area dips southwards so that the land under the habitat is sloping north-south. The alluvium acts as cushion for absorbing large scale diastrophism and thus remains a relatively flat plain. Regional diastrophism can cause local up and down warping (Chapter 1) producing minor basins and raised lands or even escarpments at places. Alluvium can easily be dislocated by the operating forces involving the energy circulation. Effect of the circulation appears as a Khadar landform. The shape of the landform depends on energy availability and its flow.

There is a continuous circulation of energy running over the lithological structure. The shaping energy has two forms, thermal and mechanical.

The thermal energy originates as part of solar radiation converted to long wave terrestrial radiation. It is apparent in the form of atmospheric temperature. The study area is a small part of the temperature regime that prevails over western Uttar Pradesh and the adjoining areas of Haryana and Delhi. The average temperature of the coolest month is above 10°C and that of the hottest month well above 20°C so that temperature is always high enough for tropical plants to grow. Part of this energy is used by precipitation. The area receives well above 100 cm of rainfall in a year, though the eastern part of the study area has slightly

more rainfall than the western part and the north eastern part receives more than the south-eastern part.[3] Precipitated water runs on surface converting thermal energy into mechanical energy through complicated processes.

The mechanical energy in the form of kinetic energy, is the chief shaping agent of the Khadar landform. Part of it is derived from the biochemical energy of organisms, but major part is derived from the atomspheric processes, *viz.*, precipitation. Rainfall water is partly absorbed as channel or surface flow of sheet water and partly by soil particles. Some of the absorbed water is drawn up by plants, some runs to water bodies as subterranean flow. Some of the subterranean flow is lifted by man as irrigation water and recycled into soils.

The moving water, specially of the channels of the habitat, acts as energy flow. The discharge of water in channel is the energy level and fluctuates with channel form (Figure 2.1), (Hoyat).[4] The most common channel form has meandering plan [Figure 2.1(A)] with *pools*, *riffles* and *shoals* (Morisawa).[5] Energy accumulates at a pool,[6] under-cutting the banks and creating a bluff there and opposite it is a shoal[7] with low energy. Energy dissipates at shoals depositing its load.[8] Average energy grades downstream [Figure 2.1(B)] moving through riffles.[9]

A cross-section of channel form with associated energy distribution is shown in [Figure 2.1(C)]. Among other things, energy level depends on the size of a catchment area and the amount of water that enters the drainage system. Catchment area can be local, covering the segment of the basin immediately next to a channel segment in question ; or it can be larger including the upper catchment of channels. Other things being equal, the Ganga has the largest catchment area, the highest discharge and the highest energy level. The Yamuna has less than the Ganga and the Hindan has the

3. The Census Atlas of Uttar Pradesh, 1971.
4. Hoyat, W.G., and Langbein, W.B., (1955), *Floods*, New Jersey, Princeton.
5. Morisawa, M. (1968), *Streams, Their Dynamics and Morphology*, New York, Megraw Hill.
6. Comparatively deeper side of a meander loop.
7. Comparatively shallower side of a meander loop.
8. Part of meander neck with maximum transport.
9. Water and sediment in a channel.

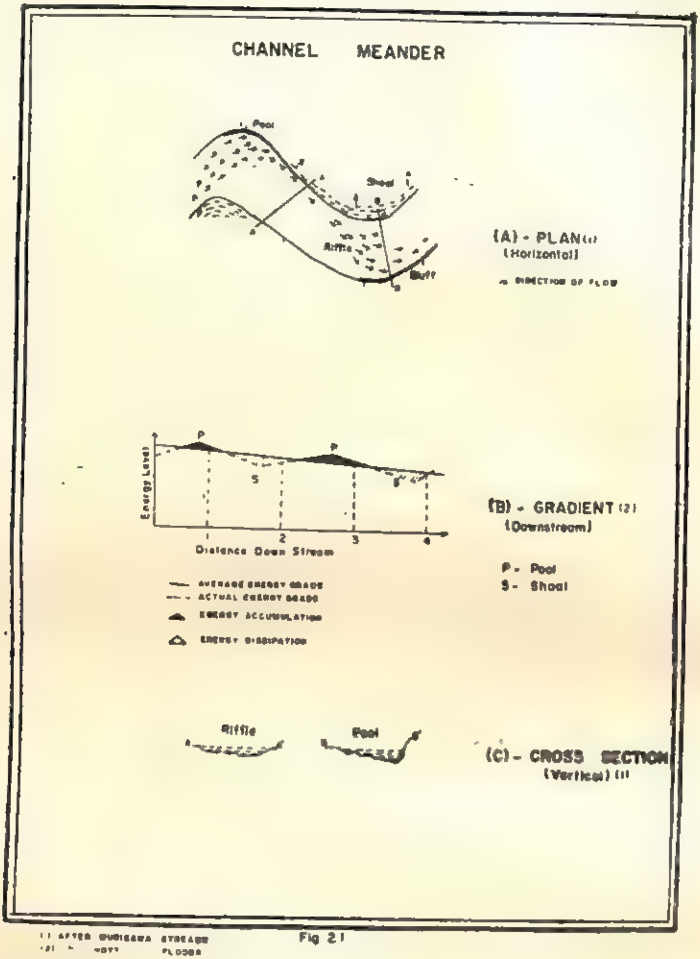


Fig 2.1

least. Correspondingly, the Ganga has the maximum development of the habitat, the Yamuna has less and the Hindan has the least development (Figure 1.1).

The energy level in a channel is highly fluctuating with time. It can rise many folds in late rainy season as in the case of the Ganga (Figure 2.2). There is an abrupt three times rise in water discharge between July 15 and July 22, 1975 when the energy level crosses from low flood to high flood.[10] It

10. Based on information provided by the Central Water and Power Commission.

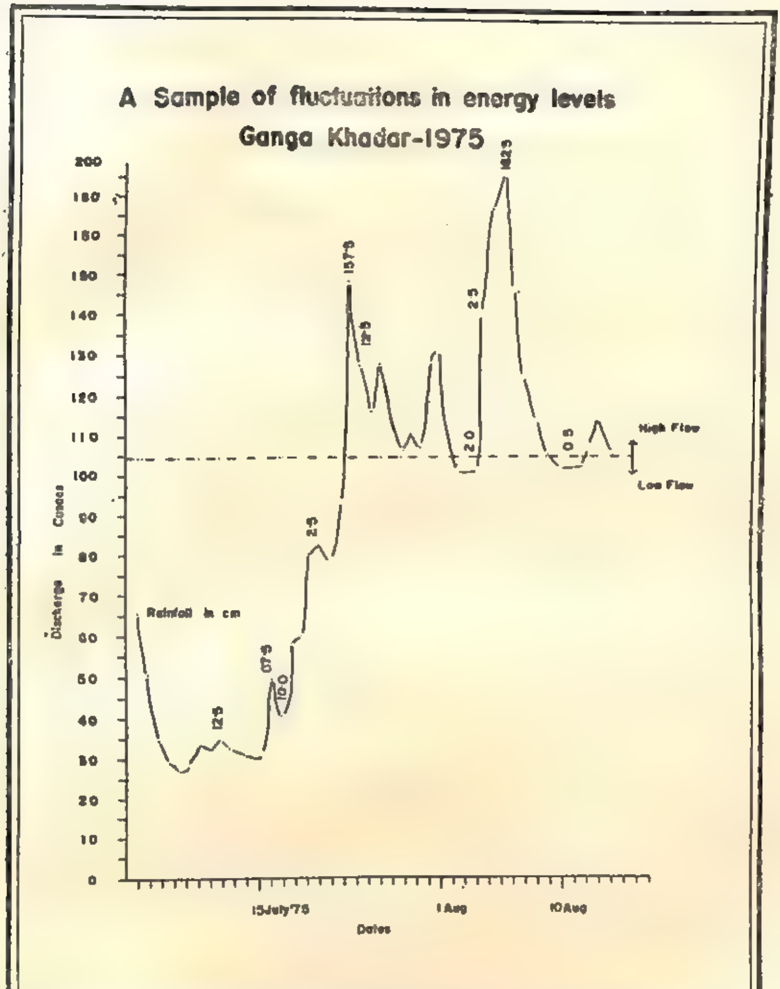


Fig 22

Based on flow measurement at Narora Barrage Narora Bulandshahr information compiled by the Central Water & Power Commission.

maintains the high flood level for about three weeks before lowering again to the low level.

Water in a channel overflows the banks at the time of high flood level forming a flood plain. Energy in the form of water covers a larger part of the habitat at this time. Perceived as *flood,* this is the essential attribute of the Khadar environment of the study area (Chapter 1). *In reality it is inundation of the parts of lands areas of the habital which are otherwise dry.* It may occur

anywhere on the earth surface. However, the inundation of the Khadar environment is directly or indirectly associated with the Khadar processes operating in the environment.

3. THE OPERATING PROCESSES

Energy of a body provides force for performing work. Work causes changes in the body being worked upon. A series of changes, linked through time, appear as a process. Body changes of the habitat produces the dynamic Khadar landform while the proceses may be classified as geomorphic and biotic.

(*a*) *Geomorphic processes* and the associated landform operate through fluvial action and mass wasting. Pedogenic regimes of calcification and salinization, along with gleization close to channel beds, operate partly as inorganic and partly as organic processes. They have been excluded from the present study as they are not related to shaping of the Khadar landform even though the product of the processes is a part of the habitat in the form of structureless soils, sand, silt, or clay in texture. On the other hand, fluvial action and mass wasting produce a distinct landform.

(*i*) *The fluvial action* includes a combined process of *erosion, transportation* and *deposition* by water flowing in one or more channels. It corresponds to accumulation, balance and dissipation of energy in a meandering channel form as shown in Figure 2.1, and results in a typical landform as shown in Figure 2.3(A). The maximum field over which channel water operates at some time or the other in the landform is called *valley flat* [VF in Figure 2.3(A)]. It is marked by existing or abandoned water courses. Water courses have variations in energy producing variations in the Khadar landform.

At places along a meander energy accumulates eroding the channel banks. It results in producing *bluffs* [Figure 2.3(A)] at the outer bends along the pool of water. It leads to dissipation of energy, water starts transporting as riffles gradually push a meander loop downstream. This is the process of *meander sweep*. Some chutes or channels are cut off from the main channel at the

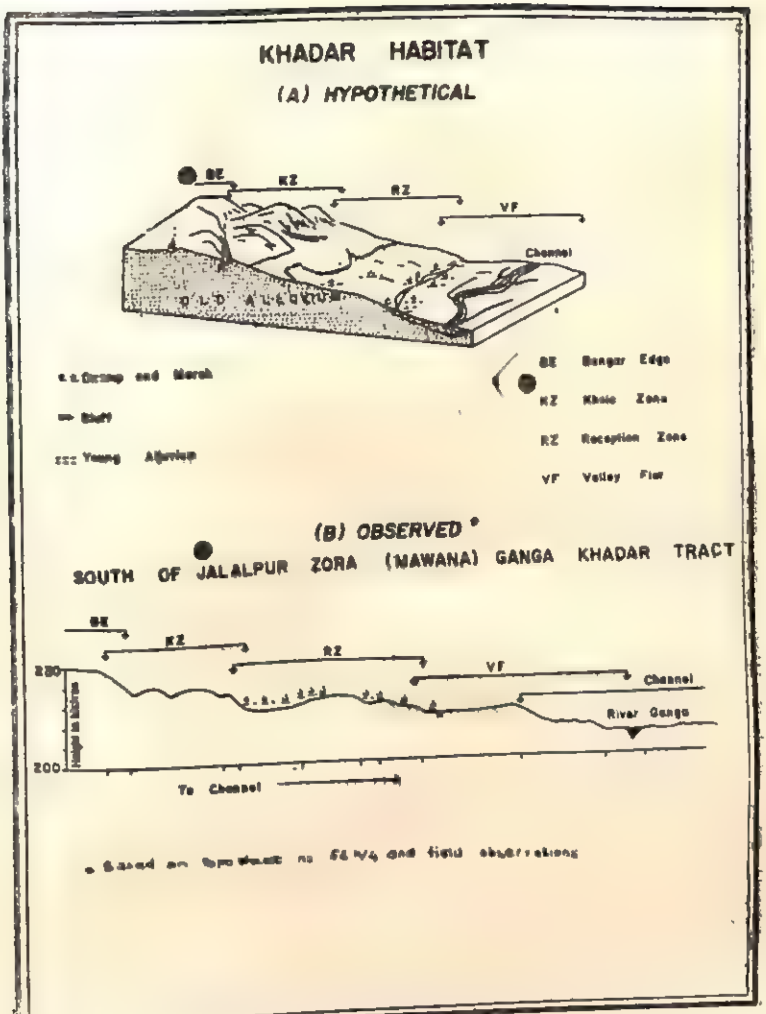


Fig.2.3

time of a meander sweep. The area covered by existing or abandoned meander is called *meander belt.*

Energy dissipation dominates at shoals or inner bend of a meander loop where river starts depositing as low arcuate ridges or *bars* within a channel bed or along shoals as *point bar* deposits. A trough or *swale* is left between two bars which is partially or fully filled by the trapped sediment. Until it is fully filled, it has the surface expression in the form of swamps, marshes or semi-

dried string channels. Horizontal plan of bar and swale arrangement is shown by dash and a dot symbols in Figure 2.1(A).

Deposition over a valley flat at the time of high flows forms an additional landform of low irregular ridges, called natural *levees.* The levees are shown as a very gentle rise of land next to the channel in Figure 2.3(A). They have the maximum elevation along the pools though sediment may spread over a large part of a meander belt. They may obstruct the surface flow on the other side from joining the main channel. The obstructed flow runs parallel to the main channel as a *Yazoo* river. Repeated spread of sediment over the same area forms a *river terrace* overlooking the channel and creating a distance between the channel and the bluffs. Each successive terrace is located at slightly lower elevation caused by constant river erosion. A normal valley flat has a single terrace as shown in Figure 2.3(A). Between and behind the patches of natural levees are shallow troughs connecting the channel to the outer land. Receding water is trapped in this back trough draining poorly along the channels, and develops *swamps* or sloughs [Figure 2.3(A)] or has moist soils. This area is called *troagh zone/Reception Zone, RZ.*

As meanders sweep downstream, each area alternatively faces energy accumulation and dissipation, hence erosion and deposition. Erosion cuts into land and deposition fills sediment into it. Land adjoining channel is filled up with young alluvium [Figure 2.3(A)] as flood plain. It covers VF and adjoining lower RZ in Figure 2.3(A). *A Khadar tract is a recent flood plain* [Figure 2.3(A)] *carved into the old flood plain that fills the Gangetic trough.*

Each channel exhibits some attributes of the landform resulting from the fluvial action along its course in the study area but the Ganga exhibits all of the attributes. A cross-section of the Ganga south of Jalalpur Zora (G-O11) is shown in Figure 2.3(B). The details of the Ganga Khadar landform in northern Mawana are shown in Figure 2.4. A meander loop curves out from Sherpur (G-020) in the north to Manoharpur (G-042) in the south. Bars and swales fill up the meander east of Hadipur (G-040). It was observed during the field work that the swale just east of Hadipur settlement has changed into a bayou due to the meander sweep.

KHADAR LANDFORMS
NORTHERN GANGA KHADAR (Mawana)

Based on top sheet No. 53 k/4

A bayou is locally called a 'Bokara'. Patches of bluffs can be seen north and south of Hadipur. The highest bluff line is shown as the badlands in the west, bordering the swampy trough zone with the Burhi Ganga. The levees at Bela (G-001) and Bhuwa (G-002) were observed to be under the channel bed as Bela-meander swept down to Hadipur. Back swamps of these levees drain through a Sota or nalla, called Soti nadi, shown in Figure 2.4. Bela-Bhuwa pool had shifted to Hadipur through the meander sweep. The map also shows three river terraces with swamps in the Upper Terrace, the Soti nadi and the Bagi nala in the middle

Fig. 2.5


Upper Terrace
Lower Terrace
Middle Terrace
TEHSIL
MAWANA
TEHSIL HAPUR
LEGEND
KHADAR LANDFORMS
CENTRAL GANGA KHADAR
(Mawana-Hapur)

KHADAR LANDFORMS
SOUTHERN GANGA KHADAR (Hapur)

Fig 2·6

terrace and the active channel east of Hadipur as the lower terrace.

Repeated deposition by the Ganga over the same area has formed the new flood plain with young alluvium extending east of

the Burhi Ganga as shown in Figure 2.4. Local upwarping (Figure 2.5) along with the constant lowering by the channel has formed three river terraces as mentioned above. Traces of upwarping are apparent partly in the form of escarments along the Terraces and partly as the raised land forcing the Burhi Ganga to flow eastwards where it joins the Ganga (Figure 2.5).[11] The channel bed is marked by the point bar deposits showing as the islands. Each terrace is located at different elevation and has its own attributes.

Close to channel is the lower terrace (Figure 2.4). Its average height is between 204 metres and 212 metres. It is characterised by islands within channel, bluffs at banks, bar and swale topography within meander loops and natural levees with sloughs at the back. The Terrace in the study area is the widest in the north (Figure 2.4), constricted in the centre (Figure 2.5) ; and indistinct in the south (Figure 2.6).

On slightly raised elevation *i.e.*, between 213 and 216 metres, is the Middle Terrace (Figures 2.3 and 2.4). It is located between levees and sloughs of the lower terrace in the east and abandoned levees and sloughs of the Burhi Ganga in the west. Nallas, sotas or streams with subsurface source drain in the middle as Baghi Nala, Soti nala or other nalas without names. Occasionally, a nalla from the upper terrace sweeps across draining to lower terrace, as south of Bhikund or Rustampur (G-045) settlement (Figure 2.4). The middle terrace terminates at Mawana-Hapur border where the Burhi Ganga swamps drain as a channel curving eastwards along the axis of upwarping to join the Ganga (Figure 2.5).

The farthest from the channel and at the highest elevation is the upper terrace (Figure 2.4). Most of the terrace is occupied by the trough zone between the abandoned levees on the channel side and the rising Bangar on the other side. Water seeping from the adjacent Bangar spreads over the terrace producing widespread marshes. Covered with vegetation, the terrace has the largest expanse of swamps. Marshes, swamps and abandoned channels collectively are known as the Burhi Ganga Swamps. It is a more or less stagnant body of water but develops a powerful current just before

11. Based on Survey of India Toposheets, surveyed in 1910-11.

joining the Ganga at Mawana-Hapur border cutting across the axis of upwarping (Figure 2.5). The upper terrace is more than the trough zone. There are slightly raised dry patches dispersed over the swamps, *e.g.*, at Sarai Khadar (G-011), Shahpur or Sultanpur (G-015) and Daulatpur or Malipur (G-032) These may be abandoned levees or colluvium deposits from the adjacent Bangar as described in the next section. The trough-zone and the upper terrace can run independent of each other. The terrace terminates at the confluence of the Ganga and the Burhi Ganga but the trough zone continues further south all along the channel The active channel flows just below the old bluff line or the badlands as in the area south of Pooth (G-147) in Figure 2.6. A single river terrace with levees, Yazoo rivers, back swamps and some old bluffs are located north of Pooth.

(*ii*) *The mass wasting* operates simultaneous with the fluvial action. The associated landform, closest to a channel, lies as the colluvium deposits in the trough zone. The process of mass wasting is initiated when the local water supply of the Bangar edge at the higher elevation dissolves particles. Since a ready slope is available towards the channel, soil solution moves in that direction converting the potential energy to mechanical energy.

The movement has the surface expression associated with the sub-surface flow of water. At times it appears as earth flows resulting in hummocky land with *terracets*, (Thornbury).[12] Slightly faster moving slumping can cause *slump blocks* with raised land and *slump scars* with depressions. These features are too localised to show on a map.

The surface flow of the soil solution forms strings of rills as line-engravings made by the running water. Some of them widen to form gullies They are very narrow valleys ranging in depth from one metre to more than 50 metres. They proceed through headward erosion into the adjacent Bangar developing tributaries in the process. As gullies close towards each other, land gets dissected by deep ravines producing badlands or the broken topography (Figures 2.4, 2.5 and 2.6). A part of the badlands yet not

12. Thornbury, W., 1954, *Principles of Geomorphology*, New York, John Wiley.

dissected by gullies appears as a hillock. These hillocks are called *Khola* or *Kholi*. The area dominated by Kholas and gullies is called Khola zone [KZ in Figures 2.3(A) and 2.3(B)]. The gullies of the Khola zone discharge colluvium collected from surrounding catchment area and deposit it at their mouths as colluvial cones in trough zone. The surrounding Bangar edge is lowered in the process feeding to the ever widening valley flat. Cones can coalesce together to form a colluvial terrace. Cones, terraces and slump deposits combine to create steeply sloping land between the Khola hillocks and the trough zone, or penetrating into the trough zone. These slopes collectively are called toe slopes shown as the upper part of the RZ below the bluffs in Figure 2.3. Individual features of the toe slopes form dry gaps in the wet trough zone. A wide area of the toe slopes is shown in Figure 4.1 east of Asifabad that has made a dry gap in the Burhi Ganga at Sultanpur.

The toe slopes and trough zone have one thing in common, the both are at the receiving end. The trough zone receives seepage water from the Bangar edge and the èntrapped overflows from the channel. The toe slopes receive colluvium from the Bangar edge. The two zones collectively are known as the *reception zone* (RZ in Figure 2.3). It is located between a valley flat on the channel side and the Khola hillocks and gullies on the other.

The gullies leading to a reception zone have yet another connecting role in the Khadar habitat. Dissecting the Khola zone they penetrate into the neighbouring Bangar through the headward erosion and become progressively shallower. The badland hillocks disappear. Instead shallow gullies appear as relatively shallow gaps in the otherwise level area. Such an area is called the *Bangar edge* (BE in Figure 2.3). It is directly feeding into the gullies and other features of the mass wasting. This is the farthest zone feeding to the Khadar landform thus acting as the last outpost of the Khadar landform. It merges with the neighbouring environment of the Bangar.

The features of mass wasting are examplified by all the channels but the features associated with the Ganga are large enough to be mapped, at least at places. An individual colluvial cone can be marked east of Asifabad (G-091) (Figure 2.5) and also at

Kishoripur (G-069). Small cones have colesced into colluvial terrace north and south of the Asifabad colluvial cone between the Khola badlands in the west and the Burhi Ganga Swamps in the east. The cone is located at the mouth of a large gully descending down from Asifabad Khola. The Khola zone of the Ganga is widest in the north (Figure 2.4), becoming progressively narrow towards the south (Figure 2.6). Khola zone is less spectacular along the other channels. It is less than ten metres along the Yamuna and still narrower along the Hindan often being absent at many places along the two channels. However, small gullies, the Bangar edge and narrow toe slopes are present along the channels even though a well defined Khola zone may be absent.

The gullies are the main architect of the mass wasting. They are responsible for a continuous dissipation of the Bangar edge. It leads to the valley widening and expansion of the physical limits of the Khadar tracts (Demarcation, Chapter 1). They operate where the fluvial action becomes insignificant, *i.e.*, at the Bangar edge. The fluvial action takes over where the mass wasting fades away, dominating over a valley flat. The two processes combined are the original shaping agent of the Khadar landform, resulting in a zonal alignment of the landform.

(*b*) *The biotic processes* work upon the landform created by the geomorphic processes. They operate by using energy supplied by plants, animals and man.

The plants are visually the most widespready organisms of the habitat. They may be natural or cultivated. Most of them belong to the family of grasses. Some cultivated plants dominate over the natural plants. The former reduces soil cohesion, coherence, enhance mass wasting and offers less resistence to the fluvial action. The natural plants check soil erosion and contribute to the rapid formation of mature soils. They initiate and enhance the process of soil formation when new land emerges from the water bed or a new slope is created. They check mass wasting and offer greater resistence to fluvial action. Natural perrenial plants, *viz.*, clumped grasses, build up stratum by arresting sediment and accumulating their dead and decomposed body on surface (Chapter 3).

The animals, like plants, provide a force for raising or lowering the substratum by accumulating their droppings. Direct raising of land is negligible, however, their droppings and rich manure to land, the soil conditions improve favouring the growth of plants. They, in turn, run the cycle of raising or lowering the substratum (Disturbances, Chapter 3). Animals have the additional role of producing the microrelief by using the same tract regularly. They engrave hoof pits and cart furrows over a cart tract. Soil particles become loose and are blown off when they are dry. Eventually the tract becomes slightly lower than the surrounding area. It appears like a gully trough in the landform. One such trough south of Kotana (Y-010), covering the tract between Luhari (Y-013) and Rajpur or Khanpur (Y-014) in the Yamuna tract had the relative height of one to three metres along the side walls of the tract when measured during the field work.

The modification of the landform by animal-force has a zonal pattern. Valley flat is the zone where animal force is mild but unrestricted. Higher up at the Bangar, the use of fertilisers for improving soil nutrient is far greater than the role of dung manure for improving soils and thereby raising the surface. The tracts tend to be better maintained and lined hence keeping away the microrelief created by the animals.

The man provides a major force in the biotic processes. On occasions man lets natural habitat be undisturbed as in the case of the islands of Latira (G-131). The common undisturbed areas are the slough, swamps, water currents or areas of steep slopes in a Khadar tract. Elsewhere man modifies the landform in various ways. He substitutes the natural vegetation by the cultivated plants. He is instrumental in forming the microrelief by letting loose animals over the newly emerged islands. He determines the location of a cart tract with the effects described above. Man accelerates or decelerates the process of inundation of a valley flat by deforestation or afforestation of the local or the upper catchment of channels.

The significance of man lies in directly producing a microrelief in various ways. He raises plinths for erecting his huts. Mud hutments are renewed each year raising the heights of the

plinths. Thus, areas under the settlements of man appear as slightly raised hillocks and tend to remain free of inundation during the raised water level in the channels. Man raises artificial ridge-like structure, called embankments, for regulating or diverting a channel flow. It creates a trough-like structure at the back of an embankment. The trough collects seepage water as well as surface run-off from the surrounding areas. Water thus pooled has barely any outlet and stagnates creating an artificial Khadar-like or *Psuedo* Khadar, conditions. Such an area is located east of the Loni (Y-046) embankment (Ghaziabad) along the Yamuna.

Man can divert a channel flow creating new areas of a Khadar tract. It is done by raising the embankments on one side of a channel. Free energy circulation is constrained by the embankment wall, therefore, is diverted more vigorously to the opposite side. Valley widening extends to the free side opposite the embankment wall often engulfing new areas under the Khadar tracts. The effect is carried down-stream. Such is the case along the Yamuna in Haryana and Delhi. Embankment has led to undirectional shift of the channel towards the east in Baghpat and Ghaziabad tehsils. Such a shift of the course has completely submerged Nagla Bahlolpur (Y-027) in southern Baghpat Tehsil covering parts of Katha (Y-026) village which was so far located well deep in the Bangar.

Man can annihilate the Khadar environment, leaving a Khadar like habitat without the Khadar environment. This is done by blocking a channel such as by constructing a dam or a reservoir upstream. The downstream channel is dried up leaving the earlier created Khadar landform without a channel flow and the subsequent Khadar environment. This is the *sub-Khadar* environment. It is represented by the Hindan south of Ghaziabad town. The Hindan water is diverted to the Yamuna leaving the former dry. The embankments raised for diverting the flow create swamps which drain as Bhuria nadi and join the Hindan just north of its confluence with the Yamuna. On the other hand, upstream of the Hindan, in Meerut tehsil, the Hindan water is joined by the Ganga water through the Jani Escape. The channel has more water than its valley would demand. A swollen river flows through a constricted valley. The habitat remains constric-

ted despite the increased water supply though this is the area with the largest spatial development of Khadar habitat along the Hindan.

Thus, man can be powerful agent in shaping the Khadar landform. He can create a new Khadar landform, modify the existing landform or erase it from the environment. An existing Khadar landform is the combined result of the geomorphic processes, modified by the biotic processes in general and man in particular.

4. THE HABITAT SERIES

The energy circulation through the Khadar processes causes body changes at the surface of application resulting in the variable extent of a valley flat. The fluctuations in energy inputs cause the variations in the extent of a valley flat as fluctuations in the output. Both the input and output fluctuations are continuous. Assuming that all the energy that enters the circulation system can initially be equated with the total potential energy, the input and the output can be represented as related curves as in Figure 2.7. Some stages of output can clearly be identified against each other as the habitat series. A habitat series can be defined as the aggregate or a set of the landform zones appended to a valley flat. A valley flat between the toe slopes and the channel is the essential attribute of the series. It is an index of the magnitude of the potential and the kinetic energy in circulation. As the magnitude of energy can be graded the habitat series also can be graded along a gradient.

The average energy circulation can be represented by the *medium series* (MS in Figure 2.7) of the habitat. It represents the steady state of the input-output relationship. The total energy level rises to form the *extended series* (ES) and lowers to a bare minimum to form the *truncated series* (TS). The parent series giving rise to the three is the *superimposed* series. It is still dominated by Bangar processes and Khadar processes are superimposed only to one edge of it. The landform dominated by the biotic modifications results in the *modified series*. Each series has its own identification.

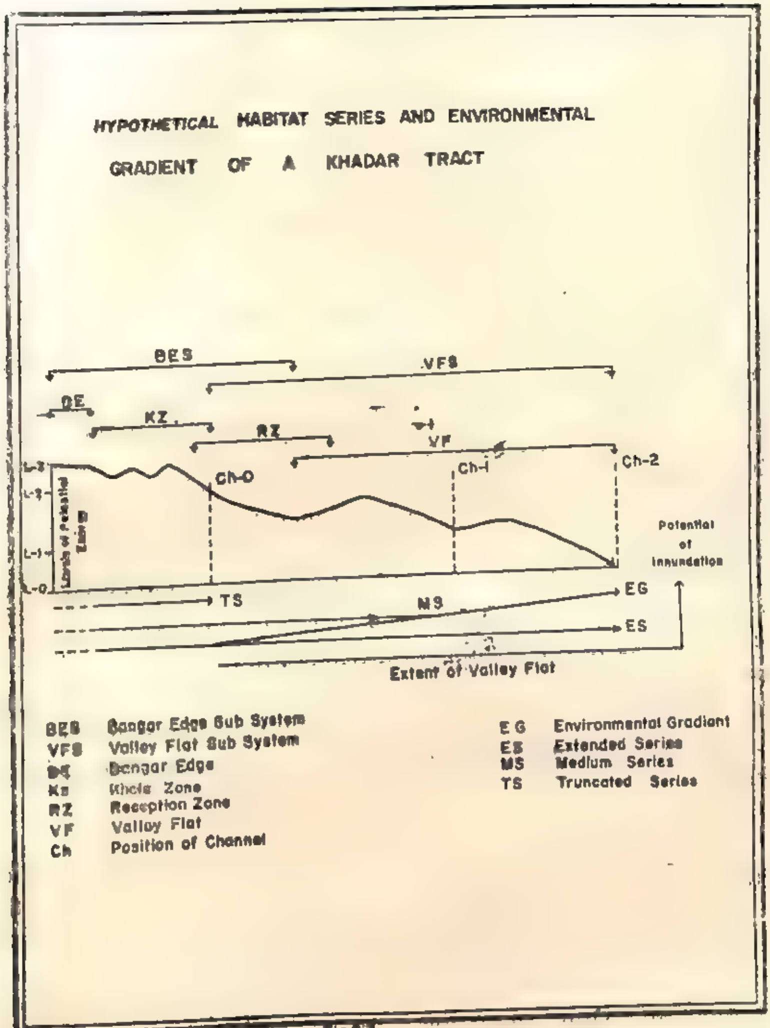


Fig.2.7

The medium series of the Khadar can be identified by a single valley flat with the medium extent (MS in Figure 2.7). A hypothetical landform of the series is shown in Figure 2.3(A). It has a single valley flat with Yazoo stream separating the back swamps behind levees and trough zone below toe slopes collecting seepage water from the adjoining Bangar (Figure 2.5). The inorganic energy shaping the landform is more than the biotic energy though the components of the energy have fluctuating level. Mass wasting

may dominate over the fluvial action at times but the fluvial action may dominate on the other times. Thus, the size of valley flat and the Khola zones are fluctuating though the two maintain a near balance with each other. An auxilary attribute of the medium series is a single row of settlements (M in Figure 7.1) at the valley flat between the toe slopes and the channel. The territorial extent of these settlements alternates between the elongated and the compact shapes.

The extended series of the Khadar habitat are associated with the repeated valley flats (ES in Figure 2.7). The levee back swamps are separated from the trough zone swamps below the toe slopes. The intervening area develops one or more river terrace (Figure 2.4). The terraces are marked by the abandoned levees, bars and channels or other features of the Khadar landform. A terrace next to the active channel can increase or decrease in size by encroaching or receding meanders. The continued depletion of the extended series by the encroaching meanders, or unindirectional swing of a channel, can revert the series to the steady state of the medium series. The auxilary attribute of the series is that it has more than one row of settlements [Figure 7.1(B)] of irregular shapes between the toe slopes and the channel. The size of each of the habitat zone may become wider than that under the medium series.

The truncated series result from continued energy depletion without its renewal. It is identified by the absence of a valley flat (TS in Figure 2.7). There may be a narrow toe slope but the Khola zone is insignificant or is in incipient stage (South of Pooth in Figure 2.6). The Bangar edge descends abruptly into channel without intervening valley flat. The potential energy at the Bangar edge is released into the kinetic energy as mass wasting starts operating at the Bangar edge where man is located [Figure 7.1(C)]. The toe slopes gain dimension, channel water starts losing energy as it starts dissipating along the widened toe slopes. The meander starts receding and a valley flat begins to form. Thus, the truncated series is a very temporary phase of the habitat.

The Khadar landform is located as an elongated thin strip along the neighbouring Bangar habitat in the *superimposed series*

of Khadar habitat. Its identifying attribute is the extent of the Bangar habitat being larger than that of the Khadar habitat. It is the parent series for others. A valley flat may be as large as that of the medium series or non-existent like the truncated series but in all cases it is smaller than the size of the Bangar area attached to it. The channel is located on one side of the series but it lacks a distinct Bangar edge with the badlands (North of Pooth in Figure 2.6). As such, its demarcation on the Bangar side is arbitrary. The superimposed series are better representative of the Bangar than of the Khadar and may be used for comparison between the two habitats.[13]

Any of the above mentioned series can form the *modified series* of the Khadar habitat. It is formed by the dominance of the biotic forces over the geomorphic forces. Energy application through the fluvial action or the mass wasting is accelerated or decelerated. As a valley flat is the essential attribute of a series, the modifying biotic forces are strong at a valley flat. Consequently, the raised parts of a valley flat may be inundated even at the time of low energy level in a channel as along the railway embankments in Figure 2.6 ; or even the low-lying areas of a valley flat may remain dry at the time of the increased energy level in a channel. Man may accelerate or decelerate forces of the geomorphic processes in the series. The presence of man is essential in the valley flat of the modified series as he modifies the flat to suit his requirements.

The above mentioned habitat series are based on the empirical findings. The Ganga tract displays all the series. There is the extended series in the north from Mawana border running southwards to Mawana-Hapur border. A sample from the middle of this area is shown in Figure 2.8. It includes settlements at the central valley flat and upper and lower terraces to the west and east of it. There is a pocket of the modified series at the central valley flat of northern Mawana, running along Meerut Bijnore highway and along the railway embankment south of Garhmukteshwar in Hapur (Figure 2.6). There is medium series between

13. As Bangar-ward demarcation of superimposed series is arbitrary, its size can be limited by not including more than one valley flat. In other words, it is not practical to include valley flat of the extended series along with a larger Bangar to create a superimposed series.

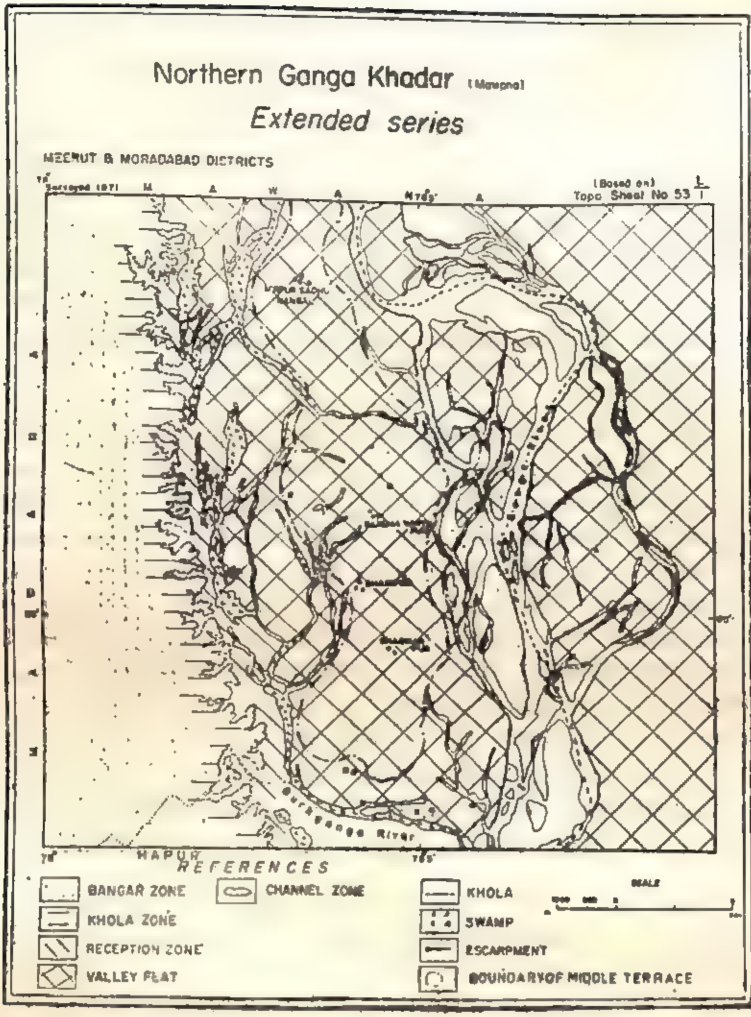


Fig. 2.8

Aidalpur (G-080) and Makhdumpur (G-062) in the central Ganga Khadar. A sample of it is shown in Figure 2.9. There is only one wet zone between the channel and the reception zone. Medium series is repeated along the Ganga in northern Hapur running southwards to Garhmukteshwar town as shown in Figure 2.6. The superimposed series is located south of Garh covering the tract upto Pooth (G-147) village in Hapur (Figure 2.6). South of Pooth is the stretch of truncated series (Figure 2.6). Thus, the Ganga is the specimen of all the Khadar series.

The other Khadar tracts do not display all the series. The Yamuna has a narrow stretch of the medium series in northern Ghaziabad Tehsil which changes to the modified series at Delhi border. Some of the villages, *e.g.*, Kheri Padhan (Y-012), North of Baghpat town have the truncated series while the rest of the tract has the superimposed series. There is no stretch of the extended series along the Yamuna. The Hindon has superimposed series alone all along its course.

Inundation. It may be recalled that the habitat series are graded using the yardstick of a valley flat. A valley flat is identi-

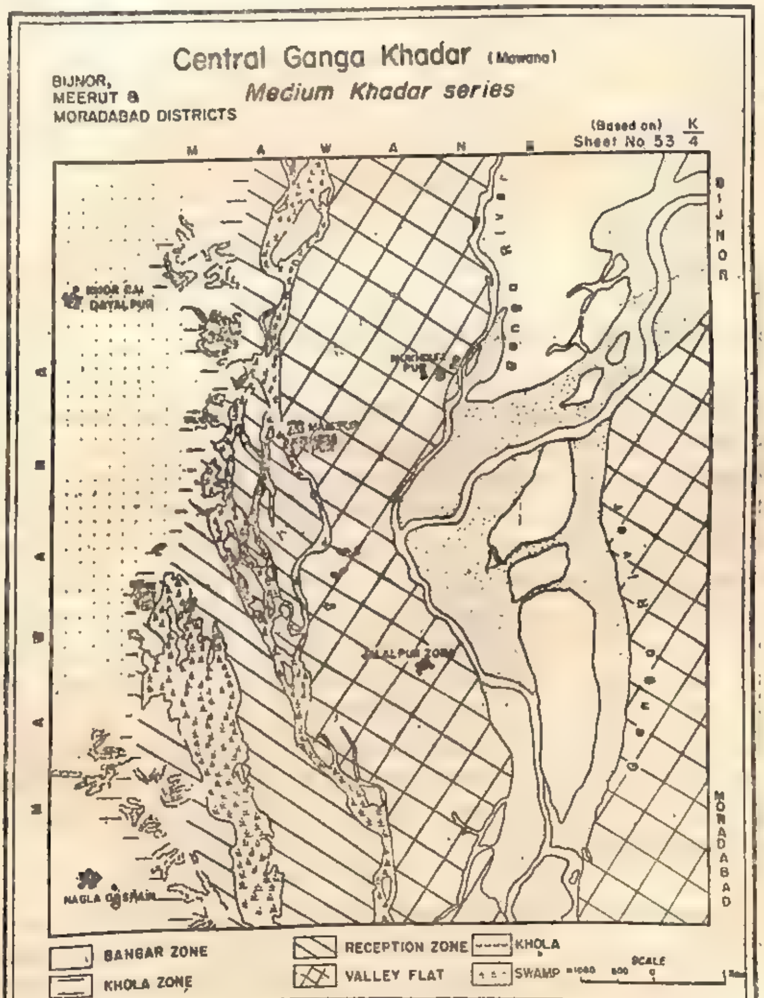


Fig. 2·9

fied by the actual or potential area of inundation. Inundation is the periodic flow of kinetic energy through flow of water running from or to a channel. It appears as the spread of water. Inundation is a mechanism to push the energy circulation to a field larger than is covered by the daily flow of energy. It is responsible for extending the Khadar habitat much beyond the immediate banks of a channel. The degree and the direction of inundation is not the same everywhere.

Pockets of raised ground such as, levees, bars and point bars, stand above the water surface or are inundated briefly at the time of high water level in a channel flow. The depth and the duration of inundation increases at the low lying areas of a valley flat, *viz.*, at those located in the trough zone or the back swamps along the channel. The inundating water originates partly from the channel side and partly from the Bangar side. The over bank flows from the channel side collect behind levees and flow parallel to the channel as levees prevent or slacken the flow of the collected water from entering the channel again. The inundating water tends to be loaded with sediment so appear muddy.

A part of the inundating water comes from the Bangar side. It originates as the sub-terranean and surface sheet flow at the Bangar upland, passes through the steep gradient of the toe slopes and flows parallel to the main channel. The flow may be too weak and shallow to form a well defined valley and flows in a broad trough. Such a flow is locally called '*choa*'. At places the gradient may be steep enough to carve out a valley which is very shallow and narrow. Such a flow is called *nadi*. Where the sub-terranean flow drains out on surface without an apparent swamp or marshy source, it is locally called *sota* (spring). The Bangar flow during rains is heavily charged with sediment. Some of it flows down along the steep slopes of gullies. Slope suddenly slackens at the trough zone where the sediment is deposited over the colluvial cones.

The water inundating a valley flat may also include the water of drains joining a flat from the Bangar side. The levees along the channel prevents drain water to join a channel immediately, hence it runs parallel to the main channel for some time before it

can find a gap in levees that would permit it to join the channel flow. These are Yazoo rivers but can hardly be differentiated from other flows of a valley flat. Rapid gradient generally prevents overflows from the drains over the Bangar even during heavy rains but as they descend to the gentle gradient of a valley flat, they overflow their banks adding to the inundation of a valley flat.

The entire valley flat is the inundation prone area if it is a single unit between the Bangar edge and the channel, *e.g.*, in the medium series. Inundation is partial in the case of the extended series where the lower terrace is inundated by channel flows and the upper terrace is inundated by the Bangar flows. The middle terrace of the extended series may remain free of inundation even at the time of high water level in a channel.

The Territorial Shape. The result of the energy circulation can be seen in the form of the shape of the village territories. They are elongated in association with the meander loops (Figure 1.1) though all the elongated territories may not contain the Khadar environment. The correspondence in shape must have started in pre-historic time when the early food producing man settled along a channel to benefit from the renewed soils and easy water availability (Riper).[14] Territories are elongated as each settlement acquires a face to a water channel. The meandering loops of a channel constantly encroach or recede from the village territories. The shape of the territories is elongated as a meander recedes and gets truncated to a compact shape as a meander encroaches into its territorial area along the channel.

Elongation roughly runs perpendicular to a channel. When a channel abandons its course, the territories appear irregular in shape as the elongation and compaction process is left incomplete and made complicated by the abandoned channels. The irregularities in shape at the uppermost terrace, just below the Bangar edge, are smoothened out by large gullies, colluvial cones and drains descending down from the Bangar edge. Many of the territories are elongated by the water courses of the trough zone. They are elongated in the direction parallel to a channel. Some of them

14. Van Riper, J.E., 1971, *Man's Physical World*, New York, Mc Graw.

become triangular or compact in shape in association with the gully mouths or colluvial cones. Territories at the Bangar edge are elongated in the same fashion as along the channel at the lower-terrace However, it lacks alternation of shapes, characteristic of the lower terrace unless the channel parallels the edge as in the truncated series. (Such would be the case under superimposed series). If the channel recedes far from the Bangar edge, the territories assume a more permanent elongated shape.

The shapes of the territories can be measured using Boyces[6] index of shape. It has been tested in the case of the three Khadar tracts. About 95 per cent of the village territories have elongated shape (Figure 1.1). Just about 5 per cent of territories have compact shape. Most of these villages are located in the valley flat over colluvial cones (Mahmudabad in Figure 4.2) or in the valley flat with encroaching meanders (Tarbiatpur—Shumali in Figure 4.2). Some of them are located in the Khola zone where the compaction is caused by the dissecting gullies (Asifabad in Figure 4.1).

The organisation in shape is broadly related to the area included in the village territories. The village area fluctuates along channel as elongation alternates with compaction. Compaction reduces village area, while elongation adds to it. The channel with large meander loops generally has large village area while channel with small loops has small village areas. Thus, large size villages are located along the Ganga and the Yamuna. The Hindan has small size villages. Central valley flat and Khola zone, dissected by many water courses or gullies, have many small size villages, irrespective of the meander loops of channel.

As the territorial extent of villages corresponds to habitat processes, all villages can be classified according to their relative location in the habitat. Thus, a village with major area over Bangar is a Bangar edge village, where a trough zone village covers largely a trough-zone depression. A Khola zone village is located over Khola hillocks and adjoining gullies and toe slopes. A valley flat village is confined to valley flat or may extend to trough zone They may further be classified as those with receding meanders and those with encroaching meanders.

The Environmental Gradient. The powerful and the common attribute of the habitat series can be used to formulate the concept

6. Boyce, R.B and W A.V. clark 1964. The concept of shape in geography. *Geogr. Rev.*, 54 : 561-572.

of the environmental gradient. It is graded along the scale variations in inundation of a valley flat, in the years of normal rainfall. The environmental grading can be centred around the medium series of the habitat (Figure 2.7). It has an average environmental grade containing a single unit of valley flat liable to be inundated. Its position is referred as MS in Figure 2.7. The environmental grade rises to a higher position (ES in Figure 2.7) in extended series of the grade. It contains more than one unit of valley flat liable to be inundated. The environmental grade drops low in the truncated series (TS in Figure 2.7), as it has no valley flat liable to be inundated, merely because the truncated series do not contain a unit valley flat. The superimposed series have larger inundation free rather than the inundation-prone area. The modified series of the habitat cannot be graded along the environmental gradient as it represents distortion of other series. Gradation is further defined according to habitat zones. Bangar edge village (*a*) lies at the lower Khadar environment. The gradient rises with Khola zone (*b*) to central valley flat, (*c*) higher magnitude of the Khadar environment prevails over the trough zone, (*d*) increasing with the valley flat of a receding meander, (*e*) with the highest gradient at the valley flat of an encroaching meander, and (*f*) the six zones together represent the average Khadar environment.

The environmental gradient is operated by individual forces of fluvial action and mass wasting. The two can be considered as vectors and can be used to describe the attributes of inundation along the gradient. Force of fluvial action operates from channel side and mass wasting from Bangar side. The two respective forces run along VFS and BES in Figure 2.7 resulting in the varying extent of the valley flat. Force VFS decreases toward Bangar and BES decreases toward channel. Truncated series is located where both the forces are marginal and potential of inundation is minimum. Such a position is occupied by point CH-0 in Figure 2.7. Level of potential energy is highest whereby kinetic energy is at the lowest. The two forces are balanced with each other with moderate potential and kinetic energy, resulting in medium series at CH-1. Potential of inundation is moderate. The force VFS is larger than the BES force. Super-imposed series can arbitrarily be placed between truncated and medium series where BES has a larger field than that of VFS. Modified series is made by accelera-

tion or deceleration of forces with reverse effect. Inundation may be reduced though inundation prone area is large or inundation may be enhanced though inundation prone area may be non-existent. The former produces super-Khadar and the latter has sub-Khadar.

5. THE CONCLUSION

The Khadar habitat is a set of the attributes producing a zonal pattern of the Kadar landform. The landform has the habitat zones as shown in Figure 2.3. These are the combined work of the geomorphic and the biotic processes. The processes operate from two different sources resulting in a zonation parallel to the channel. Next to the channel is the valley flat succeeding to the trough zone and toe slopes towards the Bangar along with Khola zone and the Bangar edge bordering the Bangar of the neighbouring environment.

The landform results from the energy circulation derived from conversion of the potential into the kinetic energy. The energy circulation maintains the dynamics of the habitat provided chiefly by the mender sweep. The sweeps constantly add or subtract to size of the Khadar habitat. Mechanism makes recognizable variations in Khadar landform as the habitat series. There is the medium series with the normal extent of all the landform zones shown in Figure 2.3(A). A valley flat extends as the river terraces in the extended series and disappears in the truncated series. The superimposed series is conceptualised as the parent habitat with the lesser spatial extent of the Khadar than the Bangar environment. A modified series is a modification of any of the other series by the actions of man. Present or potential inundation of a valley flat is the essential attribute of all the series.

As such Khadar habitat is a concept based on the phenomenon of inundation caused by a channel. The concept can be expressed as the habitat system (Figure 2.10). The fluvial action and the mass wasting are the two variables of the system as the sub-systems of the lower order. The valley flat sub-system (VFS) is marked by the actual or potential inundation in the normal years of rainfall and operates through fluvial action. The Bangar edge sub-system (BES) is marked by the mass wasting of slopes feeding

matter to the valley flat sub-system. The structure and relationship of the two sub-systems is shown in Figure 2.10.

The outermost boundaries (inset in Figure 2.10) of the habitat system are formed by the fresh water riverine system and the dry land Bangar system on two sides. Upstream it is bounded by the system of upper catchment or watershed system feeding to the channel Downstream is saline water system which is the ultimate collecting body for the water from the Khadar habitat and the associated channel. A giant sized Khadar habitat is a part of the wet and dry environment extending as an elongated strip, running along the channel and sharing the common boundaries with the neighbouring environments. The Khadar habitat system under study is a small section sliced through the giant Khadar habitat (inset in Figure 2.10). It shares the common boundaries with the riverine and Bangar systems, far removed from the watershed and salt water systems. Thus, the sectional Khadar habitat is a sub-system of the drainage system interacting with it in the form of an open system.

The circulation of energy through the geomorphic and the biotic processes sets the parameters of the habitat system. The output of the system fluctuates with the fluctuating energy inputs as the habitat series The medium series is the steady state with its extension as extended series and truncation as truncated series. Modification of the natural series caused by the biotic processes forms the modified series. The superimposed series form the ecotone between the Khadar and the Bangar habitats. The series are graded along the environmental gradient as shown in Figure 2.7. Each series is aggregate of the habitat zones which in turn are aggregates of the locational niches with the variable attributes of inundation. Thus, the output of the habitat system can be seen as set of the locational niches where some of them are drier or wetter than the others.

The Khadar habitat system would behave as a homaeostatic system if only the geomorphic processes were to operate upon it. It would have a tendency to 'converge' towards the medium series from the extremes of the extended and the truncated series in the face of the random external fluctuations. The fluctuations are

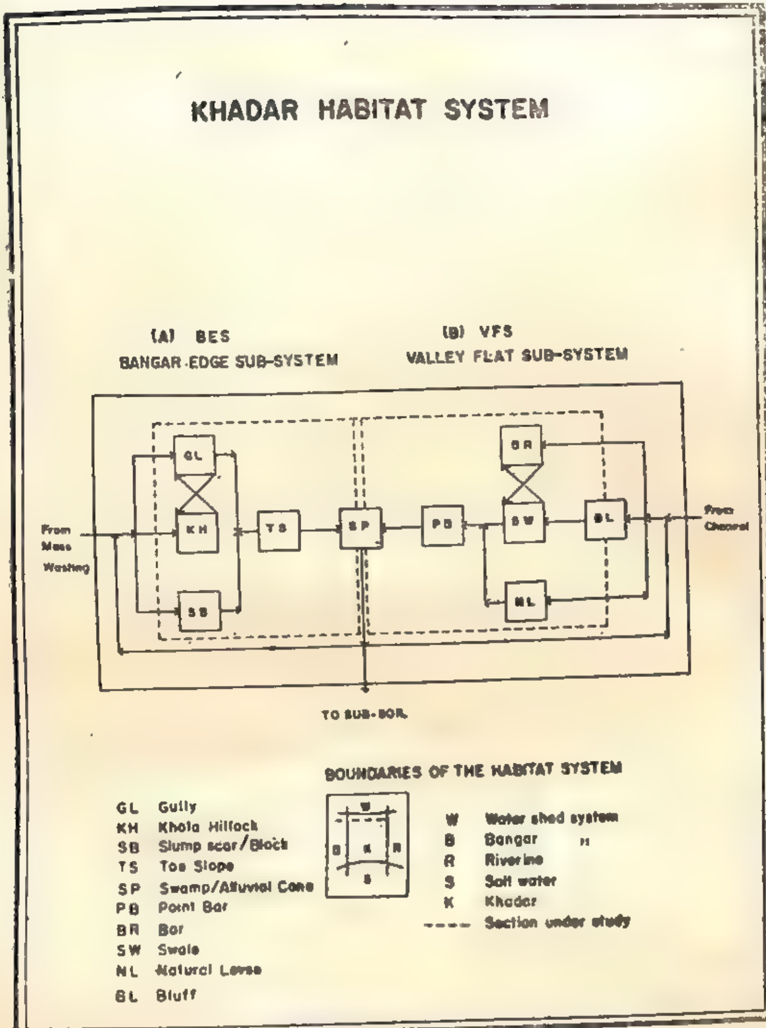


Fig 2.10

caused by man and are based on his decisions[7]. Man is an integral part of the eco-system and the habitat system operates inclusive of man's actions. The consequent habitat system behaves as an adaptive system for there exists for each possible input a set of one or more preferred states, or preferred outputs (Harvey).[8] This is the natural outcome of a system involving man as the habitat system is a part of the higher order system, *i.e.*, the Khadar eco-system.

7. Refer to Oglesby, R.T. ; Carlson, C.A. ; McCann, J.A. (Ed.) 1972. *River Ecology and Man*. Academic Press, New York.
8. Harvey, *ibid*.

3

The Khadar Biota

1. THE INTRODUCTION

Habitat is the home of organisms, man, plants and animals. Man, being the focal organism in human ecology, is singled out for study in the next and the subsequent chapters. Ecology combines mass of plants and animals as a unified element of biomass. This chapter deals with biomass as a variable in the Khadar eco-system. The components of biota, *i.e.*, plants and animals, have universal relationship in the terms of food-web[1] but otherwise function independent of each other. Plants are relatively immobile, therefore, require adjustment to local environment. Mobility of animals makes them part of a wide environment rather than attached to a local environment, such as Khadar. This is reflected in the study of the components of the biota giving natural plant associations and ecological succession along with functional categories of animals. The process leading to spatial organisation of the biomass is studied under the mechanics of distribution. Irregularities in the natural organisation are studied as disturbances which are modifying factors of the natural biotic communities. The conclusion at the end of the chapter brings out the biota as a sub-system in the Khadar eco-system.

2. THE COMPONENTS OF BIOMASS

(*a*) **Plants.** Plants as a component of Biomass have their own identity. They range in life form from small herbs to large

1. Whereby one organism supplies food to another.

trees. Many of them combine to form plant associations. Plant associations are localised plant communities characterised by one or more dominant species of plant forms whereas a plant community is an ecological grouping of the interrelated plant forms sharing a common site. The Khadar environment contains the associations of grasslands, woodlands and desert shrubs. Each association has a locational niche, occupying certain spatial location in the habitat on the basis of the drainage conditions shown in the lower part of Figure 3.1. Most of the valley flat is ill drained, the Khola zone has excessive drainage while the Bangar edge and the central valley flat have moderately drained niches. Each of them also has a functional niche, performing a distinct role in the set of interactions (watts).[2]

The grassland associations are dominated by grasses and herbs. This is the most prevalent natural association covering the entire inundation prone area of the habitat namely in VFS. Grasslands can be further subdivided on the basis of the actual condition of inundation. Some areas are almost permanently inundated or water logged growing into marsh grasslands. Slightly raised areas have only seasonal inundation, if at all, growing savanna grassland.

The *Marsh grasslands* associations grow in marshes which are poorly drained areas with a cover predominantly of grasses or other plants closely related to the grasses, such as bulrushes, reeds, canes and sedges. The ground water table in marsh stands either slightly above or below the surface, barely dropping below half a metre in the habitat. High water table is caused by saturation of soil particles with channel water and sub-terranean water of adjoining Bangar seeping towards channel. It is natural that the marsh grasslands are located along channel and in the trough zone thus centred at niches positioned at 3, 5 and 6 in Figure 3.1. In other words, it is the associations of valley flat sub-system of the habitat (Chapter 2). There would be two bands of marsh grasslands in a single valley flat in the typical medium habitat series. Bands of marsh grassland associations are repeated along abandoned channels in the areas of the repeated valley flat, *viz.*, in the

2. Watts, D. 1971. *Principles of Biogeography : An Introduction to the fundional Mechanisms of Ecosystems* McGraw Hill London.

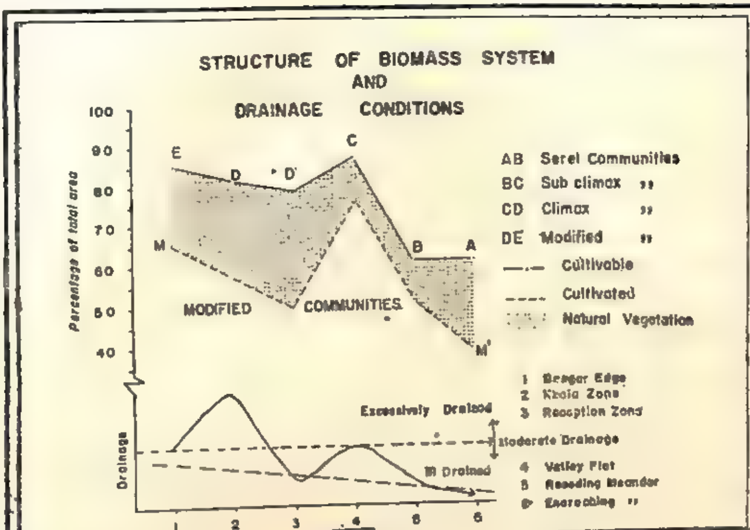


Fig.3.1

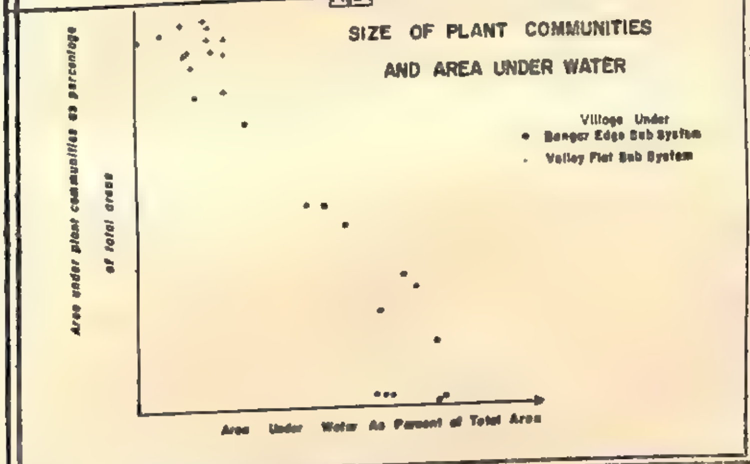


Fig.3.2

extended series. The Bangar seepage and channel back swamps may be absent in truncated series where marsh grassland, or any vegetation for that matter, may be absent. '*Kansa*' and '*Patera*' are the most common species prevailing in the association. They may be partly submerged under water, or stand above it if inundating water recedes. They may be as tall as 3 metres or more. They are coarse and unpalpatable for cattle. While Kansa grows in clumps, patera can be more continuous.

*Based on patwaris' records and the village and town directory.

The *savanna association* grows in the comparatively drier margins of marsh grasslands where ground surface has definite wet and dry conditions as at either side of the central valley flat and at the position number 1 in Figure 3.1. The water table generally lies between 1/2 to 3 metres.[3] It grows with variable spacing of the bunch grasses with patches of bare ground between them. Non-woody herbaceous plants are uncommon in the communities, except in the case of the Ganga where '*Dhak*' is common in the association. The '*Kansa*' remains a common grass everywhere. The grasses are tall, between 2 and 3 metres and coarse. In some cases grasses are surmounted by scattered palms, *e.g.*, *Palmyra* palm (*Borassus*), as in the Ganga and the southern Yamuna Khadar tracts. In other places, the grasses combine with low, umbrella shaped '*Acacia*' thorn trees, as along the northern Yamuna and at places along the Ganga. The savannas with acacia are more common in the modified communities dominated by man's intervention. The savanna and the marsh grassland may cover nearly the entire area in valley flat sub-system and occupy some patches along pathways or near settlements in the Bangar edge sub-system.

There are patches of mesophyte scrub woodland association growing at such dry places of the habitat as are inundated rarely, if at all. These are the raised parts of the valley flat sub-system centred at the position 4 in Figure 3.1 or under BES such as between the positions 1 and 2 as shown in Figure 3.1. Water table is generally lower than 3 metres. The ground coverage of trees is sparse with discontinuous canopy dominating over patches of grasses. Trees are comparatively low *i.e.*, between 5 to 10 metres. The common trees are like '*jamun*', '*katha*', 'sembul' and '*peepal*'. Eucalyptus has recently been introduced. '*Neem*' is also planted at places. Raised surface with woodland associations have restricted spatial extent in the valley flat sub-system of the medium series but are generally wide in the extended series and absent in the truncated series. These woodlands may grow near settlements and are treated as the part of the settlement area. Woodlands can occupy the entire Bangar edge sub-system but generally they have been cleared by man for extending agriculture.

3. Based on field interviews.

Alarmed by enhanced soil erosion and inundation, man has planted some woodlands in the Khola zone, as along the Ganga (Table 3.1). These raised forests are generally called Hastinapur forest range. They cover nearly the entire Khola zone of the Tehsil Mawana.

The desert shrub association has a very limited extent over steep slopes of Khola zone and toe-slopes such as the higher niches between the positions 2 and 3 in the Figure 3.1 have variety of communities included in the association. There are *ceactii* and and *euphorbia* on very steep slopes of upper gully walls. They are succulent, leafless and non-woody plants. There are sclerophylls on the gentler slopes. These plants are marked by thick cell fluids, that is frequently a milky latex. '*Aak*' and '*Arand*' (castor) are common in this variety. Some areas of steep slopes are wide enough to include Acacia. The rainy season gives a burst of many ephemerals or short lived plants, which include many flowering herbs, tuberous and bulb plants along with soft short grass, such as '*Dub*'. Desert Shrub is an association of all habitat series indicating the ecotone from a valley flat to Bangar edge sub-system.

The spatial extent of the combined natural associations as per cent of the total area is shown above the niches in the upper part of Figure 3.1. Within this each type of the niche has its own association. However, natural plant association can change slowly to adjust itself to its slowly changing local environment. Environmental changes are more pronounced in the valley flat sub-system which expands or contracts with receding and encroaching meander loops. The plants follow some sequence of changes by adjusting themselves to changes in the environment caused by the forces external to them, *i.e.*, a meander sweep. This is the allogenic plant succession of the valley flat sub-system opposed to the autogenic succession in the Bangar edge sub-system (Strahler).[4] Allogenic succession begins with hydrosere of the submerged niches tending to compete with trees at dry niche. There are five categories of

4. Strahler, A.N. and Strahler, A.H., (1973), Environmental Geoscience : Interaction Between Natural Systems and Man, Santa Barbara, California, Hamilton.

Seral vegetation (Weaver and Clements)[5] undergoing the succession. The succession begins at positions 5 and 3 and moves towards 4 in Figure 3.1.

1. The *submerged category* of plants are submerged under water. They can grow upto the depth of 6 metres of water (Weaver and Clements).[6] They have very thin leaves and long, thin tube-like stem, firmly rooted in the soils deep below the water surface. They grow with rhizomes[7] and occupy pools of channel as well as parts of swamps (*jheels*) or wet patches in the trough zone or ponds of the Bangar. Examples of channels side category were observed during field work at Latira (G-131) and the Bangar edge category near Loni (Y-046).

2. The *floating category* of plants invade the area where and when the depth of water flow decreases to less than 6 metres but upto about 2.5 metres. They float on water surface with roots in soils under water. The stems have broader tubes with thick leaves filled with air and stomata closed from watery edge. They grow with tubers along rhizomes, *e.g.*, water hycinths or lillies. They generally occupy the inner parts of a river meander, *i.e.*, at shoals, '*jheels*' and other shallow water bodies in the valley flat sub-system and shallow margins of ponds in the Bangar edge sub-system. There are extensive areas of water hyacinths in the Loni area (Ghaziabad).

3. The *reed-swamp category* of plants invade the areas where and when the depth of water decreases to less than 2.5 metres. Lower parts of these plants stand under water, rooted in the sub-surface soils. The upper part with seeds stands above the water surface. They are the most extensive plants in the trough zone and the point bar deposits within a river meander in the valley flat sub-system and along irrigation channels, *nallah*-like water bodies or shallow pond margins located in the Bangar edge sub-system.

4. The *sedge meadow category* of plant grows when and where the surface becomes dry, though soils close to the surface

5. Weaver, J.E. and Clements, F.E., (1938), *Plant Ecology*, Bombay, Tata McGraw.
6. *op. cit.*
7. Roots propagating by external growth.

are still moist. It is one of the transitional phase of the valley flat sub-system but a more stable characteristic of some areas in the Bangar edge sub-system. These plants are dominated with tussocks or clumps of hard fibrous grasses, *e.g.*, 'Kansa'. Between clumps there can be patches of turf of 'Dub'.

5. *The trees* can invade the area when and where water table is lowered still further but drainage remains unchanged. The trees would be mesophytic, *e.g.*, '*Katha*', if water table is not very deep, *i.e.*, within 3 to 6 metres ; or halophytic, *e.g.*, palms, where soils are saline or alkaline, and xerophytic, *e.g.*, '*Keekar*', if the water table sinks further very low, *i.e.*, to less than 3 metres. Water table is rarely lower than 3 metres in the valley flat sub-system hence xerophytic trees are rare but are common at the the slopes and the tops of the Khola hillocks in the Bangar edge sub-system. The trees form individual stands or small groves as forests or orchards. The orchards of '*luquat*', '*Ber*', guava and mango groves may be common close to the roads and the towns in the Bangar. Forests are most common in the Khola zone though may occupy the raised areas of the valley flat (Table 3.1). Many of these may have been planted by forest department of Uttar Pradesh to check erosion of the Khola zone. The areas emerging from the receding meanders may be covered with forests where palm trees are common.

Any of the above mentioned categories can become permanent in a locality where further succession has been arrested by nature or by man. The arrested category may occupy the niche for hundreds of years as Sub-climax vegetation. The first three categories mentioned above are the sub-climax vegetation of the wet parts of the valley flat and the Bangar edge sub-systems. The drier parts of the environment develop sedge meadow category but soon the land is cleared for cultivation unless recaptured by a meander sweep. Nearly the entire dry area of the two sub-systems is covered with cultivated plants.

If not cleared for cultivation, the dry areas develop woodlands as allogenic succession approaches its climax. The dead and decayed parts of plants accumulate on ground, raising the sub-stratum. Thus, the canopy starts getting denser and the micro climate is changed. The environmental factors thus are changed

by plants themselves. They adjust to their new environment by following a sequence of change, called autogenic succession. This succession is a part of the Bangar edge sub-system. It may extend to raise the parts of the valley flat sub-system where the growth of woodland association is possible just as the allogenic succession of the valley flat sub-system may extend to the Bangar at the drying margins of the ponds and the lakes, as often observed. However, a prevailing association can at least partly be cleared by man for the cultivated plants.

There are associations of cultivated plants or the modified communities, growing along or replaced by natural categories of plants as shown in the central part of the Figure 3.1. They replace the natural vegetation in sedge meadow or higher categories. They occupy an entire Khadar tract except at the badlands, swamps, channels and the built up areas. The cultivated crops change seasonally. Winter is the main cropping season where sowing is done during October, November and December and harvesting during April, May or June. This crop is called 'rabi'. It is followed by summer crop under irrigation as main crop of the monsoon and is called 'kharif'. It may be sown immediately after harvesting of 'rabi' or may be sown one/three months later, but before the sowing season of the rabi crops. There may be the additional crop called 'zaidi', which is grown before sowing the main crop of 'rabi' or 'kharif'. It stands in the fields for one to three months. Each cropping season has its own crop association as shown in Figure 3.2 generalised from the various habitat zones of the three Khadar tracts (Table 3.2).

The rabi[8] is dominated by food crops *viz.*, cereals, in all the habitat zones and all the Khadar series. About 80 to 100 per cent of the area under rabi is covered with food crops, *viz.*, wheat as shown in Figure 3.2. Non-food crops occupy less than 5 per cent of the cultivated area, average being less than 2 per cent in a valley flat sub-system raising to 5 per cent in the Bangar edge sub-system. Non-food crops are dominated by the fodder crops which can also be used as green manure. The fodder crop is nearly absent in the valley flat sub-system. Thus, rabi is virtually a single species crop of wheat. However, the variety of wheat is

8. Based on *chittha rabi*, 1974-75.

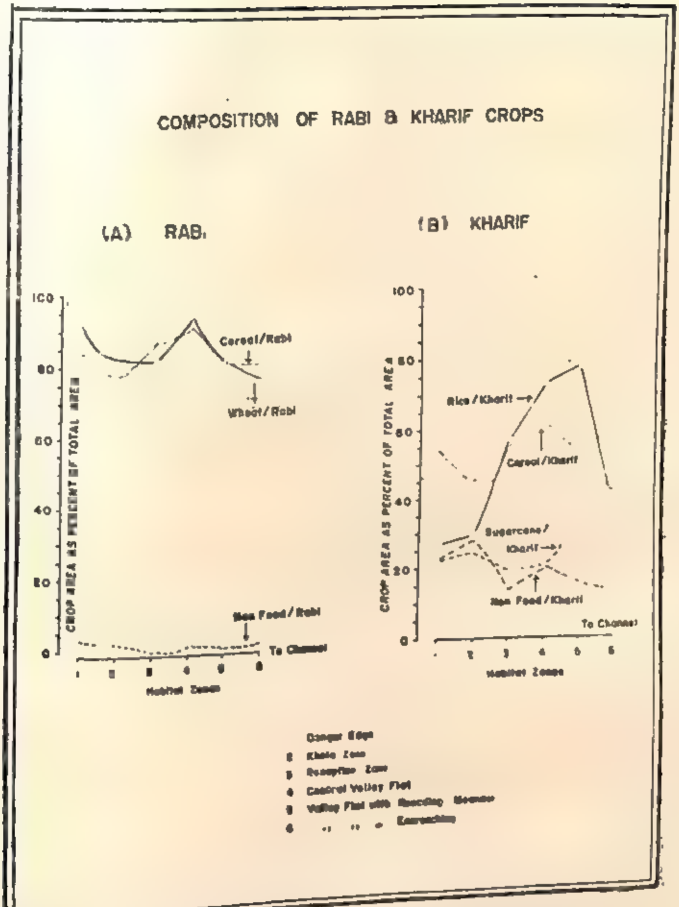


Fig 3.3

not the same everywhere. High-yielding hybrid wheat prevails in the Bangar edge sub-system while *desi*, low yielding variety of wheat stands over the unirrigated land in valley flat sub-system. Rabi grows uninterrupted in all the habitat zones as shown in Figure 3.3. Swamps, marshes, the Khola badlands and the channel bed are the only exception.

The kharif[9] coverage is contiguous under BES but is missing over the low lying areas of VFS (Figure 3.2). The acreage is dominated by the food crops *viz.*, cereals which account for about 55 per cent of the total kharif production of VFS and about

*Based on patwaris' account 1974-75.

9. Based on *chittha kharif*, 1974-75.

50 per cent of the Bangar edge sub-system (Figure 3.2). The food and the non-food crops may have almost equal share among the cultivated crops. Thus, Jamalpur Meghraj (G-013) and Birkhera (G-029) in Table 3.2, covering a large part of the Bangar, have 59.66 per cent and 45.83 per cent respectively of the non-food in the kharif. However, 80 to 90 per cent of the kharif acreage in some areas under the valley flat sub-system continues to hold the food crops alone. Thus, Nawada Khadar (G-146) and Pooth Khadar (G-147) (Table 3.2), located exclusively in the valley flat of the southern Ganga, have no non-food crop in the kharif. Unlike the rabi, the kharif season does not have any single species dominance among the food crops. Rice dominates with 50 to 80 per cent of the kharif production of the valley flat sub-system, specially in the areas of long inundation (Figure 3.3). Most of it is '*Aghani*', or late crop, depending only on inundation water. Rice becomes insignificant with less than 30 per cent of the kharif of the Bangar edge sub-system or is '*Sawani*', *i.e.*, early crop which depends on irrigation rather than on natural supply of water. Sugarcane is sub-dominant with 20 to 40 per cent of the acreage in VFS and about 20 per cent in the Bangar edge sub-system (Table 3.2 and Figure 3.3). The areas of sugarcane and rice are mutually exclusive. The acreage of crops varies from village to village within a habitat zone (Table 3.2) but sugarcane avoids the areas of long inundation.

The rice and sugarcane as the combined kharif crops equate with the percentage of wheat in 'rabi' under VFS but not under BES. This is because of the increasing varieties of the other crops grown during the kharif. Rice is replaced by the increasing share of the other grains, *viz.*, maize and bajra in the Bangar edge sub-system. Maize grows along the drier Hindon whereas bajra grows along the Yamuna. Cotton, oil seeds, pulses and various non-food crops are grown as the kharif crops in the Bangar edge sub-system. Proportionate share of the non-food crop is much more in the kharif than in the rabi crops (Figure 3.2). The acreage is more than that of sugarcane in BES but decreases towards the channel. Apparently, kharif is the season of varieties and species diversity among the cultivated crops just as the natural vegetation has a burnt of herbs and forbs in the season.

The kharif cropping season has not only an increased variety but also increased acreage under crops (Table 3.3) despite its disappearance from the low lying areas of VFS (Figure 3.3). In nearly all the villages of each the habitat zone kharif acreage is more than the rabi, the exceptions being the villages in the valley flat sub-system located along a channel or the trough zone. Inundation is responsible for lower kharif acrage in these areas. If inundating water remains stagant, it can be used for growing rice but very often these areas develop fast current of water that washes away top soils or seedlings. Such areas are not cultivated for fear of losing money invested in sowing. On the other hand, the kharif acreage can be as high as three times that of the rabi at places in the Bangar edge sub-system (Table 3.3). These are villages covering the Kohla zone and the steep slopes of the Bangar edge with deep (24 metres) water table. These areas are dependant on natural supply through rainfall, hence grow the kharif crops, but as land becomes dry during the rabi, the acrage of the cultivated plants dwindles to 1/3 of the kharif acreage.

The zadi[10] is grown at the Bangar edge and in the dry channel bed (Figure 3.3). The crop includes a large number of the cultivated plants belonging to the family of gourds, melons and cucumbers, potatoes, sweet potatoes and tomatoes, along with beans which are grown as food, fodder as well as green manure. The creeper plants, such as the first three, are called *Palej*. Many areas in the valley flat sub-system have only post-rabi zaidi crops growing palej of cucumbers, melons and gourds. This crop is harvested along the channel as long as the water level does not rise in the main channel following the melting of snow in upper reaches. Harvesting may last longer along the trough zone where water level rises following rainfall in local catchment area. The rising water level inundates the crop land and entire crop is washed off overnight.

The zaidi of inundation prone area is grown with dry farming technique. A hole is dug in the soils to the depth of water table. Seeds are planted in the hole and the germinated seeds are protected with mat covering against frost or chilly winds of late winter. Covering is removed once plant creeps out from the hole.

10. Based on *chittha rabi* and *kharif*, 1974-75.

More and more area is brought under the parej cultivation as water level recedes with the setting of winters. Thus, a large part of the channel bed remains covered with palej till water level rises once again. Creepers of palej are grown in the Bangar edge sub-system, specially near the towns but they are well irrigated and manured. Such areas have zaidi along with fodder, green manure or some vegetables.

The plant association of the cultivated plants has greater acreage than that of the natural vegetation except at the Khola and the trough zones and at the channel bed (Figure 3.3). In the absence of the actual figures, the area under natural vegetation can be approximated to the cultivable area[11] minus the cultivated area. Approximate area of the natural vegetation and the cultivated area are compared in Table 3.4 and plotted in the upper portion of Figure 3.1. It is based on the averages of the habitat zones. The area under EA and MM curves is the area under the natural vegetation. Below MM curve is the area under cultivated plants shown as the modified plant communities.

The area under natural vegetation decreases from 30 per cent at *A* to 10 per cent at *B* (Figure 3.1), in accordance with the improving drainge conditions extending from the channel to the central valley flat. The size of the cultivated area drops to a bare 35 per cent of the total area and varies proportionately with the area under water in the encroaching meander. The expansion of the cultivated area is constrained by the prevailing communities. These are *seral*[12] grass land communities which are liable to change with shifting meander loops. These communities do not succeed to the sedge-meadow category which can be reflected by the modified communities. Hence it is the zone dominated by *Seral Biomass* communities.

The coverage of the natural vegetation is barely 10 per cent between *B* and *C* in Figure 3.1. This is the subclimax vegetation of the reed-swamp category. This is an arrested climax as the higher categories are replaced by the cultivated plants. The coverage of the cultivated plants rises to about 80 per cent with improved drainage.

11. Cultivable area=Total area—Area not available for cultivation.
12. Plant community at a stage is plant succession.

The area under natural vegetation increases from 10 to 30 per cent at *D* in Figure 3.1. Thus, the climax vegetation of the savanna or marsh-grasslands is associated with excessive drainage at the steep slopes. The size of the cultivated area drops close to 50 per cent of the total area though cultivable area rises above 80 per cent. Vegetation undergoes the ecological succession climaxing into the communities suiting to their local environments of the excessive slope or stagnating water. There is some afforestation in the area which is actually a restoration of the natural vegetation that must have existed long ago. Afforestation further increases the area under natural vegetation. Thus, this is the zone dominated by the climax communities.

The coverage of the natural vegetation drops to about 20 per cent at *D* in Figure 3.1 as drainage improves to become moderate. It covers the Bangar and its edge extending to the central valley flat. The cultivated area stays well above 65 per cent of the total area, the cultivable area rises above 85 per cent. Thus, the cultivated area of the Bangar edge sub-system is about three times the area under the seral communities. This is the modified biomass community in the Khadar eco-system located in the Bangar edge sub-system with its extensions over parts of the central valley flat. The raised parts are larger over the repeated valley flats than over a single one. For that matter, the extended series has a large area of the modified communities at its seral tracts than the extent in a modified series.

At least 50 per cent of the area is covered with the cultivated plants at all the niches. Maximum of 40 per cent of the total area lies under the natural vegetation while about 10 per cent of the area is not available to any form of plants. This available area is either built up or is under water. The area under the combined plants vegetation decreases with the area under water over the area of VFS (Figure 3.4). The area under water varies from village to village and from year to year in association with a meander sweep. Thus, Bahbalpur (G-037) at an old levee does not have any area under water while Dupedi Chao (G-070) under a submerged meander has 100 per cent of the village area under water. There is no such relationship between area under water and the vegetation in BES. The area under vegetation stays around 90 per cent irrespective of

the area under water though the latter is barely over 5 per cent in any village of the BES. Thus, the cultivated plants are the major component of the Khadar biomass both in the valley flat as well as in the Bangar edge sub-systems.

The scarcity of fooder is related to the scarcity of the cultivated land. The kharif or summer crop is generally not sown as the fields are inundated. Where kharif crop is raised rice becomes the prevailing crop which can withstand inundation (and the ensuing alkanity of soils) better than the fodder crops. The fodder crops can be destroyed if water stands in the fields for more than three to four days. The scarcity of fodder may force the cows to live on weeds or on the course of 'Kansa' and 'Patera' grasses growing in the area. The scarcity of fodder keeps low yield of milk and cows remain the localised means of subsistence for man in the Khadar eco-system.

(*b*) **Animals.** The animals supplement the plants in composing the biota. No single set of animals has the locational niche exclusive to the Khadar habitat or a part of it. As a result of their mobility animals can at times enter and leave the Khadar environment despite the fact that some animals may have greater association than others with some attributes of the Khadar environment *e.g.*, sheep and goat around the steep slopes of the Khola zones, though they can be located elsewhere too. More significant is the functional niche of the animals in the Khadar eco-system. Functional niche (Watts)[13] is the role played by the organism in question in running the eco-system. Animals can be classified in the categories of wild and domesticated, according to their functional niche.

The domestic animals, crossing the Khadar environment, are largely cows, buffaloes, sheep and goat, though there may occasionally be other animals like pigs, dogs, hens and fowels.[14] The first four have well defined functional niche in the Khadar eco-system.

The Cows dominate numerically at the valley flat along a channel. A domestic cow can barely be differentiated from the

13. Watts, *ibid*.
14. Based on field surveys.

wild cows. Domestic cows are tended by owners' households. Cows may be obtained free of cost or for a sum barely exceeding two hundred rupees. Most of the farmers can afford to own at least one cow. Most of these cows yield just about one or two litres of milk per day. Milk is consumed by householders' family. Yield of milk is low as there is not enough of proper fodder for them.

The buffalo heads are generally fewer than cow heads at a valley flat. A buffalo can cost any amount exceeding Rs. 1,000 depending up on its breed. Not many householders can afford to make an initial investment with the subsequent risk of death due to diseases so that the buffaloes are owned by fewer households and are fewer in number than the cows. They are susceptible to catch water born diseases, especially in their mouth and limbs (FMD), hence they have to be well protected against the inundating water form diseases. Generally buffaloes are moved out during rainy season from the inundation prone area. They cannot sustain on weeds hence generally fodder crop is raised for them. This is possible only in the area where there is enough cultivable land to spare some area for fodder besides food and other crops needed for man's subsistence. This is easily facilitated in the areas of the double cropping which are either inundation free or have a brief period of inundation. Generally, these are the irrigated areas of the raised parts of a valley flat or areas in the Bangar edge sub-system. Yield of buffaloes ranges from 4 to 5 litres to 15 to 20 litres a day, depending on its breeding. Generally, daily yield is more than that can be consumed by an owner's family, hence milk is for sale. This requires transactions with the neighbouring areas, *viz.*, towns. Some households may be involved in regular dairy industry if they own one or more good yielding buffaloes. Thus, buffaloes involve interactions between different spatial segments of the Khadar in a wider environment.

The sheep and goats occupy the driest locational niches of the Khadar habitat. They are generally located in the areas surrounding the badlands of the Khola zone. Sheep graze close to the ground while goats browse on the herbs and forbs or thorn weeds of the Khola zone and the toe slopes. Occasionally a household may own one or two goats for subsistence of the family. More often, households of some castes like Gadariya (shepherds) and Banjaras

(gypsies) and harijans, own more than ten sheep or goats. The products are for sale involving the interaction between the different spatial segments of habitat, as in the case of the buffaloes. The fleece of sheep is generally sold raw at the collecting centres which are generally cooperatives, *e.g.*, Khadi-Gram Udyog. Goats' milk is generally sold to the vending dudhwallas or milkman; more often goat is raised for meat to be sold in the neighbouring towns. Thus, sheep and goat like buffaloes, become a part of the wider interactions of the eco-system.

Apart from the above mentioned four, there are occaionally other domestic animals. An individual harijan house-hold may raise pigs for sale. Recent Sikh migrants raise chickens partly for subsistence and partly for sale. Travelling Banjaras bring a bunch of horses and dogs with them. A part-time migrant of the high caste often brings a horse along with him moving from the adjacent Bangar. These animals are too few and randomly distributed to have any distinct functional niche in the eco-system.

There may be innumerable species of the wild animals and each species may include innumerable individuals. Barring a few, wild animals do not have any identifiable role in the human ecosystem but often require interaction between the areas under VFS and BES. Fishes of water bodies located in the VFS are angled by man located in the BES and sold in the urban markets, though occasionally an individual in the VFS may catch some for his food requirement. These are wild cows perhaps restricted to the valley flat of the Ganga. These are called *Dhana* by the local people. They move in herds and often graze on the standing crops. Farmers stay awake to chase away wild cows at night. There are some game animals at the valley flat along the Ganga channels. These are *Pahara* (spotted dear) and wild boars. The urban people of the adjoining areas occasionally camp in the area for the shooting games. The Ganga Khadar in southern Mawana, near Sarangpur (G-109) village at Mawana-Hapur border is particularly famous as the hunting ground. Hunting provides temporary employment to the local people who help the hunters in raising the *Machan* or in some other work. Thus, the game animals provide a link between the Khadar and the non-Khadar environments.

It can be concluded that the animals of the Khadar environment have their own contribution in the eco-system. Domestic cow has inevitable but a localised functional niche and dominate in VFS while buffaloes dominate in BFS. Sheep and goat cover the Khola and the reception zone, and along with buffaloes help in integration of the eco-system. Though less defined, they have locational niches like plants resulting in a spatial pattern associated with the mechanism of distribution.

3. THE MECHANICS OF DISTRIBUTION

The mechanics of natural distribution of plants and animals is governed by the patterns of dispersal and behaviour. It is modified by man's interactions, described in the next section.

The dispersal is the spread of species from one point to another. Each species has its dispersal field or the positive area (Krebs)[15]. Dispersal field of the animals is constrained by distribution of land and water which in turn corresponds to the habitat zones described in the previous chapter. Terrestrial animals are restricted by wide, deep and fast flowing channels located only at the margin of the eco-system. Therefore, land animals have few negative areas.

The plants and animals occupy a small given locality or niche within the dispersal field. Organisms occupy a niche only if the attributes of niche suit their behaviour. Behavioural adjustment of the plants are faster than the dispersal adjustments. The animals have slower or lesser adjustment. They can move out of the area if the local environment becomes unsuitable to them. Water availability is the chief attribute of the niches requiring the behavioural adjustment. It depends partly on water supply to niches and partly on retention of water by the niches. Both the factors in turn are dependent on other factors.

The Water Supply to niches can be natural or augmented by man. Natural water supply originates as rain water in the upper or local catchment of a niche. Though there are slight variations in local rainfall (Chapter II). these are offset by flow from the surrounding catchment area that drains to a river channel. As such a valley flat sub-system eventually has more water supply than

15. Krebs, C.J. 1978. *Eeoiogy, The Experimental Analysis of Distribution and Abundance*, Harper Row, New York.

a Banger edge sub-system. As water from a tributary ultimately drains to a main channel, water supply is maximum in the valley flat sub-system of the main channel and less in that of the tributaries. Thus, water supply is maximum in the Ganga, less in the Yamuna and the least in the Hindon Khadar tracts.

Man augments natural water supply through irrigation. Possibility of augmentation to a niche depends on the nature of the terrain where a niche is located. Augmentation is possible in the slightly undulating to a gently sloping areas which can retain the water supply. Irrigation through flowing of water is not possible over very steep slopes where, augmented water would drain off immediately. It is only possible with mechanical spraying though its cost is high. With such constraint, the badlands and the slopes of a Khadar tract are not irrigated while other areas have possibility of the augmented water supply.

The realisation of the possibility of irrigation can depend on the nature of irrigation. Irrigation can be extensive in the areas using canals. Privately owned wells/tubewells/pumpsets irrigate the restricted areas belonging to the owners or users hiring water or pumping set from the owners. The Khadar habitat offers river irrigation to the areas where a water course flows close to the cultivated areas. Main channel is edged by sterile sand, therefore, not used for irrigation. River irrigation is practised in the areas where a Bokara (Chapter 2) or chute from a meander neck or bayou runs close or through the cultivated fields located in the Bangar edge or the valley flat sub-systems. River irrigation through bayous was observed during the field work along the Ganga South of Mirzapur (G-078) and at Kheri Padhan (Y-012) along the Yamuna North of Baghpat town. No such area was observed along the Hindon. River irrigation of the Ganga augmented water supply in the valley flat sub-system while the Yamuna provided to the Bangar edge sub-system.

The variations in the means of the irrigation have their own bearing on the actual size of the area with augmented water supply (Table 3.2). The area under irrigation broadly becomes smaller towards the channel and the trough zone. Irrigated area has the widest spread along the Yamuna where more than 50 per cent of the cultivated area is irrigated. About 50 to 90 per cent of the

area is irrigated by canals. The Hindon has the lesser irrigated area where canal irrigation is less important than well and tubewell irrigation. The irrigation pattern varies from village to village along the Ganga. There are areas such as Asilpur (G-109) where the privately owned wells and tubewells irrigate about 50 per cent of the cultivated area while in Paswara (G-144) 100 per cent of the irrigated area is through canals. Most of the villages in the valley flat sub-system are unirrigated except in a few cases, *e.g.*, Mirzapur (G-078) with 11 per cent of the irrigated area using tube-well irrigation, compared with 2 per cent in Khanpur Garhi (G-087) and 45 per cent in Mishripur (G-113) using river irrigation. In general, there is a decline in irrigated area towards a channel especially in the Ganga Khadar. Relationship between the extent of the irrigated area and the drainage conditions is such that the irrigated area is maximum at the moderate drainage and nil at the excessive and impeded drainage. Maximum extent of the irrigated area occurs at the Bangar in the superimposed series declining in general towards the valley flat along a channel.

The efficacy of the augmented water supply depends on the water retention of niches. This in turn depends partly on drainage conditions and partly on the soil factors. The two operate simultaneously though can be studied separately.

The drainage conditions may broadly be graded along the average slope of an area. There can be three types of drainage conditions, moderate, excessive and impeded as shown in the lower part of Figure 3.1. Assuming soil factor to be uniform over the area, different types of drainage conditions can have different effects on the water retention at niches :

(*a*) Moderate drainage is widespread at the gentle slopes as at the Bangar edge, occasionally at level tops or some point bar deposits of the abandoned meander loops at the middle terrace. The average slope is 1° to 3°[16]. Water drains off neither too slowly nor too rapidly. It can be available to the niches for sufficiently long period for plant growth. Such areas are occupied largely by the domesticated plants, *viz.*, wheat and sugarcane.

16. Based on field measurements.

(*b*) Excessive drainage is characteristic of the steep slopes as in the Khola zone and the toe slopes. Average slope is 3° to 45°. Water drains off too rapidly to be available for mesophyte plants. Such areas can have xerophytic plants, though during rainy season herbs and forbs may shoot up over the area.

(*c*) Impeded drainage with anaerobic conditions is the characteristic of the basins and depressions as in the trough zone and depressions of the valley flat. Poor drainage may be caused by as gentle a slope as less than 1° or by the raised water table. Such areas are occupied by swales at the various terraces and gaps between natural levee at the lower terrace. Either water does not drain at all or drains so slowly as to keep soils permanently wet. Such areas are covered with stagnant water or have table very close to the surface, varying from 1/2 metre to 3 metres. Vertical penetration of roots is impeded, but horizontal growth is extensive developing rhizomes. Shoots are thrown up in clumps, where they grow as tussocks.

The drainage conditions can be super-imposed on landforms zones as shown in Figure 3.3. All the four habitat series have the three types of the drainage conditions though the areal extent varies according to the dimensions of each zone. Superimposed on the drainage conditions of niches are the soil factors affecting the capacity of niches to retain the supply of water. Though soils of the three Khadar tracts fall in the general category of alluvium soils they can be further classified as young alluvium in the valley flat sub-system and old alluvium in the Bangar edge sub-system (Figure 2.1). Young alluvium is structureless, coarse, has mixed texture and is underlain by impeded glei horizon. As channels deposit silt each year they are perpetually in the process of being formed, therefore, are immature and poor in soil nutrients and restrict plant growth. Old alluvium is mature, has loamy texture and is often rich in soil nutrients and capable of holding abundant plant growth. Some of the old alluvium washes down to a valley flat through flows of mass wasting operating in the Bangar edge sub-system.

The alluvium can be further differentiated by soil texture. Channel water deposits coarse texture sediments next to itself while

finer texture is carried farthest away. On the other hand, Bangar flow deposits coarse soil particles at the toe slopes and trough zone while finer sediment can be carried further down to the channel. As a result, there can be pure sand next to a channel as well as at gully mouths in the reception zone. Interesting example of such a case is provided by the medium Khadar at the confluence of the Ganga and Burhi Ganga. Sediment from Asilpur (G-108) and Saidpur (G-117) Kholas flows towards the Ganga. Coarse material is trapped by the Burhi Ganga and fine clay is deposited at valley flat in Sarangpur (G-109). On the other hand, the Ganga deposits coarse sediment along its bank at eastern margin of Mishripur (G-113) but there is loamy texture near the settlement in the West, boardering Sarangpur on Bangar side. More often, sand from one source gets superimposed on silt or clay from the other. There are thin layers of sand, silt and clay superimposed on each other, lying in small pockets, scattered at random in the valley flat system of all th series.

Such a mixture of texture has a mixed reaction on water availability. Water percolates easily through sandy soils so that they are always dry. Clay soil has too narrow pore spaces to let water pass through, hence clay beds tend to be water logged. In fact, many of the swamps in valley flat sub-system are not the result of depressions or basins but pooling of water over clay pans, *e.g.*, swamps South of Tarbiatpur Janubi (G-095).

Clay deposits are not always related to the distance from source. They result from chemical reactions which can be located anywhere within or outside the Khadar environment. Accumulation of clay forms a hard pan where water from any source stagnates to cause water logging. Further addition of water to these areas results in flooding similar to inundation in the valley flat sub-system. This creates a Khadar-like environment, or *psuedo Khadar*, which is not related to channel flows. Clay deposits have the effects of abundant water supply creating a marshy environment. It may grow marsh-grassland plant association but may lack wild animals of the valley flat sub-system in the face of constant poaching on animals by man of the surrounding areas.

Sand deposits also are not always associated with channel flows. There are patches of sand, known as 'bhur', located in the

deep interior. The origin of this sand is not known. It may have been deposited by winds blowing persistently from deserts or may be the reminiscent of the till plains of the pleistocene glaciation.[17] The 'burs' of the Bangar are shallow, compared to sandy deposits of the valley flat and may hold associations barely different from the surrounding areas. Sands of the valley flat may be bare of the natural plant associations though may hold cultivated seasonal crops of cucumbers, gourds, melons, etc. In brief, sand deposits are always associated with the poor water availability.

Soil and other related factors form three categories of water availability affecting niches. There is abundant water availability in the valley flat sub-system. Surface may be dry due to sand but sub-surface particles are saturated. Water availability is nil or poor in the ecotone covered by the toe slopes and Khola zones. It is moderate in the Bangar edge sub-system. As a result water loving plants and animals abound in the valley flat sub-system. Desert communities of plants and animals would occupy the ecotone and mesophyte plants and land animals would be common in the Bangar edge sub-system. There are no water tight compartments among the categories as similar niche characteristic can be located in the contrasting environments.

A niche may suit the behaviour of more than one organism. It leads to competition and symbiosis amongst them. This is the universal feature of organisms and not a distinguished attribute of the Khadar eco-system. Even taking an account of competition and symbiosis, spatial pattern of plants and animals would be as has already been described. However, the prevailing spatial organisation of the biomass is far different from that expected from the natural mechanics of the distribution. The irregularity in the prevailing organisation is the disturbance in the natural organisation.

4. THE DISTURBANCES IN THE NATURAL ORGANISATION AND THE BIOTIC COMMUNITIES

Plants and animals of a given locality are not always adjusted to the niches indicating disturbances in the natural mechanism of

17. *The Northern Ganga Flood Plain*, NAO, 1965, Calcutta, India.

distribution. It modifies the natural spatial patterns. It may be provided by nature or by man.

Nature provides disturbance when a new escarpment is formed, such as, when a bayou or a meander loop is thrown open over a new area. A previously dry niche may turn wet or *vice-versa*. Thus, a tree may appear to be located in the midst of a channel. The sedge-meadow category may spread along a canal as at Hadipur (G-014) where part of the settlement site was submerged during the period of field work in 1976. Unadjusted state of organisms is temporary. It is wiped off and replaced by the new set of organisms adjusting to the changed niche characteristics. Such changes are frequent at the valley flat, specially along the lower terrace. It is also common at the Bangar edge where gullies or Kholas expand the toe slopes.

Man disturbs the natural pattern in an organised way. He intervenes directly with the patterns of the natural vegetation. Animals may be affected indirectly. He causes deforestation or clearing of natural vegetation. Cleared vegetation may include timber or fuel wood, or herbs and forbs grazed by cattle. He may destroy vegetation by fire, accidental or by design.

Man may replace natural vegetation by the cultivated plants. Clearing follows the sedge-meadow or higher categories of the plants in the succession. Natural replacement occurs at the dry niches of the Bangar edge sub-system and raised parts in the valley flat sub-system. Survey of India topographic sheets printed in 1910-1911 show natural vegetation in the areas which is replaced by cultivated plants in the new sheets surveyed in 1976-77,

Man may introduce plants in otherwise bare land. These are cultivated plants, *viz.*, 'palej', grown in the channel bed which emerges dry after water level in the bed is lowered at the end of winters or early summers. The emerging sandy bed is reclaimed for growing 'palej' crops mentioned earlier. It is grown with dry farming techniques and stands in the fields till the water level in the channel bodies rises following the melting of snow in the upper reaches or heavy rainfall in the local catchment area. These crops are introduced before the appearance of the hydriarch succession.

when the submerged or reed-swamp categories begin to grow. Crops have to be protected rigorously. 'Palej' may not always be planted in the pioneer areas. It may be planted as irrigated crop of the Bangar edge sub-system. It is a pioneer crop only of the emerging channel bed.

Man may introduce weeds in the shallow water bodies. This is generally done to reclaim the margins of lakes and ponds for agricultural or other purposes. The common weed introduced is '*Samudra Sokh*'. Once margins are reclaimed, weeds continue to spread. Deeper parts of the water bodies may turn into swamp or marsh. Water table may rise in the surrounding areas causing salinity of the soils. Large scale reclaimation through weeds was observed at Abdullapur (G-128) near Jharina (G-118).

Large scale reclaimation of land and filling up water bodies causes more wide spread and deeper inundation. Flow of inundating water becomes faster. A channel changes it course more swiftly and frequently. This in turn changes the pattern of natural vegetation as mentioned above. Man takes to afforestation to avoid and check such a sorrowful experience. Afforestation implies planting of trees by man. Most of them are planted by local or State Governments. The Uttar Pradesh Forest Department has planted many forests in the Khola zone of Mawana, *e.g.*, near Hastinapur in the north and Kishoripur (G-069) in the centre along the Ganga. Some palm groves, or forests, have been planned by panchayatas at the valley flat, *e.g.*, at Kishanpur Khadar (G-035) and Hadupura (G-077).

The natural and man-made mechanisms operate on the biota to form the prevailing biomass communities of the Khadar. These are formed by splitting the natural plant association or superimposing the additional elements on them. Hypothetical biomass communities are shown in Figure 3.1. The communities would occupy narrow zones running parallel to a channel in the case of a single valley flat of the medium series. This is a narrow zone that alternates seasonally between water in a wet channel bed and 'palej' in a dry channel bed. The second zone follows the reed-swamp category associated with the game animals.

The third category includes the cultivated plants along with the remnants of the sedge-meadow and woodland associations over the raised parts of a valley flat. Cow as domestic animal may dominate at the low lying areas along a channel accompanied by buffaloes at the higher areas. The fourth category includes the arrested hydriarch series of the submerged, floating and reed-swamp associations spread over water of the trough zone. Some of floating category may be associated or reclaimed by man for agricultural and other purposes.

The fifth category includes the desert-shrubs or planted forests at steep slopes of the Khola zone and toe slopes. The Bangar edge in the vicinity has the sixth category including the cultivated plants with the remnant woodlands and the sedge-meadow. Sheep and goat dominate functionally, some of them may descend down to the adjoining valley flat. The Bangar edge merges with the Bangar that has the cultivated plants in combination with buffaloes and cows as the domestic animals.

Some of the communities between channel/palej and desert/forest may have the repeated zones in the extended series. Channel /palej in truncated series may run parallel to the Bangar edge with the cultivated crops accompanied by cows and buffaloes as the domestic animals. The superimposed series is formed by combining some or all of these zones to a much larger area of Bangar. A modified series has a larger area of the cultivated plants than the area of the natural vegetation. As mentioned in Section II, more than 65 per cent of a village area is covered by the cultivated plants in these areas. It covers most of the Bangar to its edge and extends down to the raised parts of the valley flat, *e.g.*, the middle terrace of the northern Ganga Khadar. It may be noticed that the evolved Khadar series remain essentially the same as the habitat series of the previous chapter except that the modified series become more extensive.

V. THE CONCLUSION

The biota as a variable in the Khadar eco-system is primarily operated by the component of plants in general and the cultivated plants in particular. The component of animals share the Khadar environment with a wider environment. The dominance of plants

appears in the form of the biomass variable of the eco-system assuming the various shapes as the plant association, *viz.*, grassland association of marsh and savanna, woodland association of forests or orchards and, what is the most widespread, the association of the cultivated plants.

The plant association in particular and the biota in general interacts with the habitat system (Chapter 2). The continuous interaction results in the allogenic succession dominating the valley flat sub-system and the autogenic succession dominating the Bangar edge sub-system. One type of the interaction may appear in the other sub-system indicating that the sub-systems are not exclusive. Man interrupts the natural succession by arresting a category or replacing it by the cultivated plants.

The biotic variable of the eco-system behaves as a system of the lower order within the higher order eco-system. It has the components of plants and animals as the two variables or sub-systems (Figure 3.4). The various plant associations are interrelated variables within the plant sub-system as shown by the linking arrows in the illustration. The plant sub-system (*A*) has broad relationship with the animal sub-system (*B*). The biotic system is normal as a medium biomass series. The variable of plant sub-system is repeated in space in the extended series. The truncated series of the biota contain a narrow zone of the modified association of plants while the other associations are absent. The modified biotics series is composed chiefly of the modifed associations. Man interacts in the eco-system to keep away other associations. Some or all the variables of a normal biotic system operate along with the oversized modified association in the superimposed biomass series. Apparently the biota and the habitat series can be interchanged without modification of the systems. It is the natural outcome of the biota and the habitat as the common variables of a single system, *i.e.*, the Khadar eco-system. The seriess of the two variables are given a common name of the Khadar series in the Khadar environment.

The output of the biotic system is the variable size of the modified plant communities in the form of the cultivated crops *MM'* (curve in Figure 3.1). The output corresponds with the output

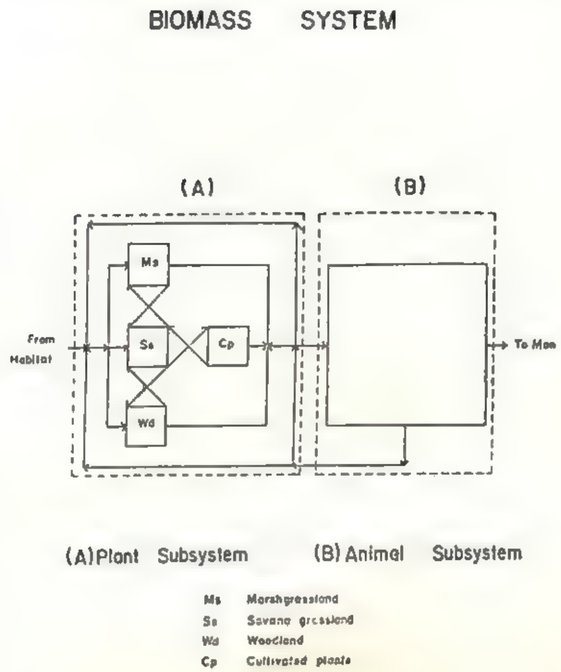


Fig.-3-4

of the habitat system indicating a close relationship of the two. *The size of the modified communities is such as to vary between 20 and 80 per cent of the total area of an inhabited village while the remaining area is either covered by the natural plant communities or is unavailable to plants.* The area of the crops can increase to more than 80 per cent or decrease to less than 20 per cent where a village is uninhabited. Thus, the output of the biotic system is closely related to man in the eco-system.

4

Man at Population Level of Organisation in the Khadar Eco-system

I. THE INTRODUCTION

Man is the focus of study in human ecology. He is a complex environmental variable related to himself and to the other environmental variables. The relationships operate at the individual level but are better discernible at the population level. Population is an aggregate of the undifferentiated individuals It has some attributes which are summarised from the attributes of the aggregating individuals but also has some additional attributes not found in the aggregating individuals, *e.g.*, sex composition, age structure and density. This chapter studies the attributes of the population of man as a variable in the Khadar eco-system. The variable has a spatial structure related to the habitat and biomass systems. As such man concentrates at the Bangar and disperses to the raised parts of a valley flat. The spatial structure results from the mechanics of distribution, *viz.*, dispersal to some positive areas which are favourable to man from the point of view of water supply. The spatial structure resulting from the pattern and the mechanics of distribution are constantly changing setting the dynamics of the distribution. Some of the patterns and changes cannot be explained by the normal Khadar processes. These are the disturbances in the population structure. The last section on conclusion summarises the salient features of the population as a system.

2. THE SPATIAL STRUCTURE OF POPULATION DISTRIBUTION

(*a*) **The Numbers.** The individuals aggregating as a population are dispersed in clusters, called *clumps.* Its spatial boundaries can be defined at some chosen scale. A population clump, at the lowest scale occupies the territory shared by a unit family. However, the family members may be widely separated from each other for any reason and the spatial boundaries of a family unit may not be easy to define. The territory for counting the individuals in an aggregate can more easily be identified at village or local level. A village level aggregate of population is a cluster of families. Thus, defined a clump is an aggregate of the individuals counted within a common boundary of a village. Except where specified, a clump and a census village are synonymous. Exceptions occur where a census village holds more than one clump at different hamlets. However, neither the census date is available hamlet-wise nor the actual numbers of hamlets, often, discovered during the field work, correspond to that reported by census. Under these constraints, each village is assumed to contain only one hamlet and population of a clump assumed to be clustered at the site of main hamlet of a village.

A clump has some attributes which are derived from the individuals aggregating as clump but are not part of the member individuals. These attributes are the integral part of the clumps alone. Thus, an individual is always unit but the population has numerical variations. The variations can be measured in one dimension as numerical distribution or in more than one dimension as the density patterns.

The numerical distribution is the spatial variation in the counts of individuals in a clump forming the clump size. It forms the frequency distribution of clump size using the framework of the static Khadar habitat. The clump size has a wide range within a Khadar tract, for example, Ropra (G-022) with the total of 2 persons[1] and Agwanpur (G-081) with 5,099 persons are located respectively under the VFS and BES of the Ganga. The range is greater along the Yamuna with only 6 persons in Ahmadnagar

1. Based on 1971 Census.

Nawada (Y-048), and 9,664 persons in Chhprauli T.A. (Y-004) with locations in BES alone. The Hindon has smaller range in clump size with 73 persons in Afzalnagar Siti (H-059) and 4009 persons in Asalatpur or Faruknagar (H-065) under BES. The locations under the valley flat sub-system have small size clumps while Bangar-edge sub-system has the larger clump size. The size-disparity in the samples from the Ganga is shown in Figure 4.1. The valley flat villages East of the bluff line have size smaller than 100 persons, with three exceptions, while those under the Bangar edge sub-system in the West of the bluff line are larger than 500 persons with two exceptions. The disparity is less marked under the medium series (Figure 4.2).

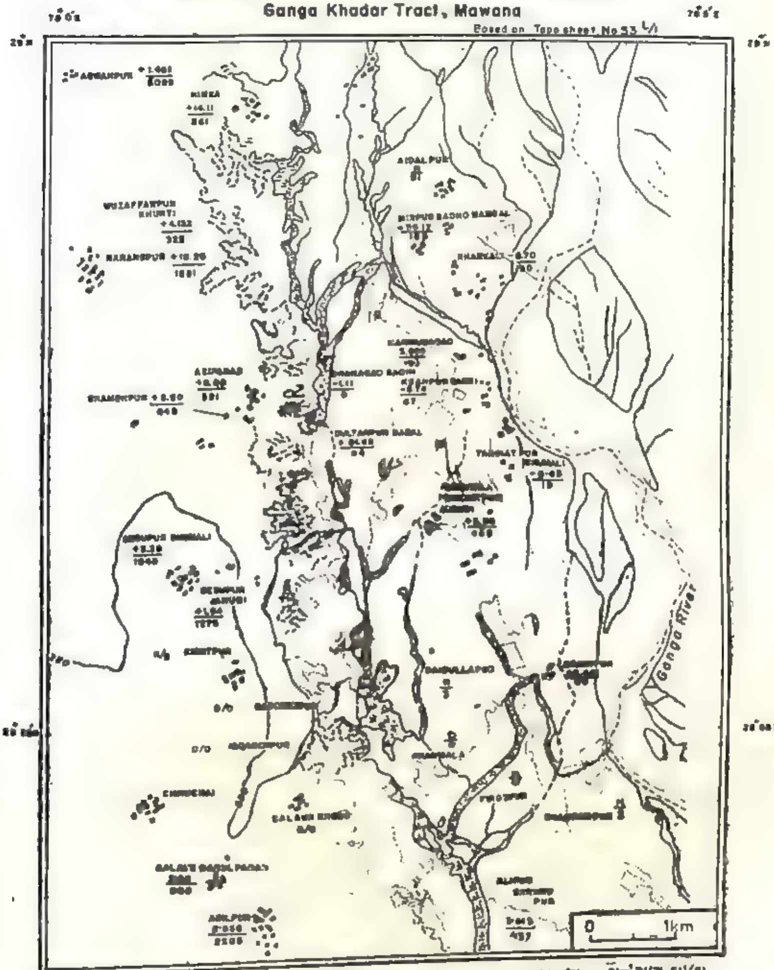
The numerical scatter of the clump size can be measured better by the summary statistic of the arithmetic mean or the average. The average at the Ganga is 423 persons, while the average for the Yamuna and the Hindon is 1,805 and 1,152 persons respectively. The prevalence of the small size in the Ganga tract can be explained by the numerical dominance of the valley flat villages over the Bangar edge villages. Barring the central valley flat, the average size under VFS is much lower than the average under BES.

The degree to which the mean value actually represents the degree of crowding in clumps can be measured by the mean variance ratio (Pilou).[2] Where there is no dispersion, all values would crowd at the mean and the ratio would be zero. The ratio would increase as dispersion increases. The Khadar tracts have a high degree of dispersion as the ratio is greater than 1 : 1000, where the v ariance is greater than 1,200 in all the cases.

Despite the variance, the numerical distribution is statistically normal. About 10 per cent of the cases along the Ganga and 19 per cent of them along the Yamuna have the clump size greater than the mean plus or minus standard deviation. A sampled population of a part of the valley flat of the Ganga shows a good fit for normal distribution (Appendix C, Table 4.1). The values greater than the range of mean plus standard deviation indicates

2. Pilou, E C. (1969), *An Introduction to Mathematical Ecology*, New York, John Wiley.

Clump size (71) and growth $(\frac{71-61}{61})$ in an Extended Series, Ganga Khadar Tract, Mawana



N—New Clump '71, D—Depopulated Clump, Growth rate in percent per annum/Clump Size '71 (71–61)/61

Fig. 4·1

a large clump size while mean-minus standard deviation stands for a small size of a clump.

The above mentioned measure brings out some significant regional variations. About 40 per cent of the clumps of the Ganga Khadar tract are small with 288 persons or less in the size while only 10 per cent are large with 1,196 persons or more. The small clumps include the villages with zero size (*i.e.*, the uninhabi-

Clump size (71) and growth $(\frac{71-61}{61})$ in a Medium Series, Ganga Khadar Tract, Mawana

Based on Topo Sheet No. 53 K

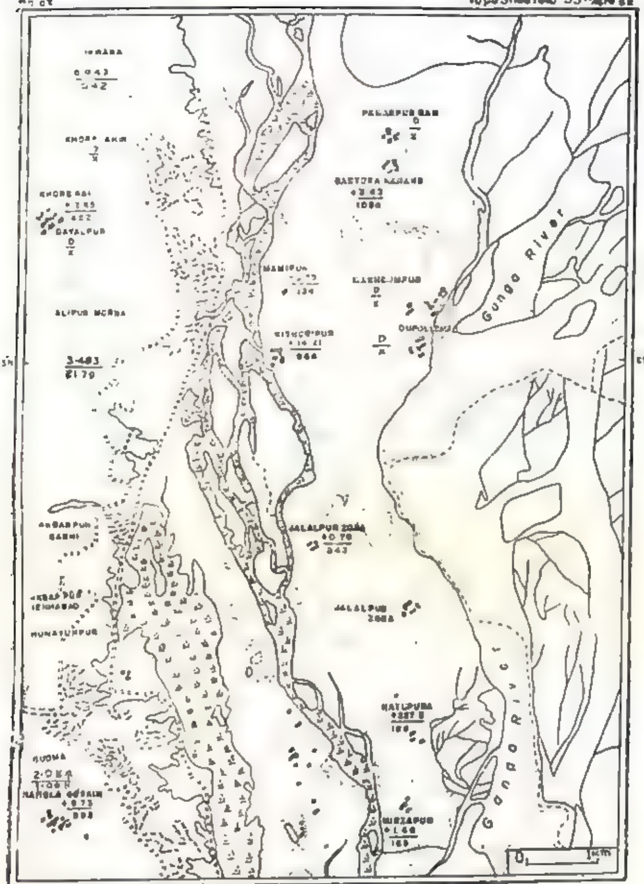


Fig 4.2

ted villages) which are 23 per cent of the total of the census villages. The Yamuna has 10 per cent of the small and 15 per cent of the large clumps. The small size of the Yamuna tract contains less than 358 persons while the large size has more than 3,432 persons. About 80 per cent of the clumps of the Ganga tract are located in the area under valley flat sub-system and are small while about the same proportion of the Yamuna includes the clumps located in the Bangar edge sub-system and are large. It can be generalised on this basis that the clumps in the Bangar edge sub-system are larger in size than those in the valley flat sub-system.

A working hypothesis can be raised on the basis of the above mentioned trend. In a random sample of clumps from the Khadar tracts, the probability of finding a large clump at the valley flat would be as low as the probability of finding a small clump at the Bangar where the size is measured as a fraction of the total population in a tract contained in a particular clump. If the relative number of large clumps is very small in a moderate size of the observed cases, the probability of finding a large clump in the sample would be very low and approximate the poisson distribution, such as

$$pr\ (i) = \frac{e^{-m} m^r}{r\,!} \qquad \ldots(1)$$

where probability, *pr*, is the probability of occurrence of a large clump ; *m* is the mean density, *i.e.*, number of large clumps/total number of clumps in the sample, and the *r* is the proportionate size of a clump. The probability, *pr* (*i*) can be measured for fractional size *r*(*i*), *i*=1, 2, 3,..., *n*.

The hypothesis is tested in a sample of 81 villages of the Ganga (Appendix C, Table 4.2). The area has 17 villages where clump size is greater than 0.6 of the unit population of the 150 villages. The clump size expressed as the fraction of the total population of the tract is called the fractional size. If the unit population as the aggregate of the all clumps is divided equally among the locational niches of the 150 villages each one would have 1.23 per cent of the total population of the set. The probability of finding clumps with 1, 2, 3,.. ..., 7 per cent would follow the probability distribution as shown in Table 4.2 of the Appendix C.

The observed pattern fits well with the expected pattern. Only 28.4 per cent of the clumps would have size greater than 4 per cent of the total population and 71.5 per cent clumps would have small size. The test confirms that there would be few clumps at the valley flat where individuals would aggregate forming the large fractional size.

Significantly the large size is a derived parameter based on the probability model rather than being defined arbitrarily. As

most of the observations in the sample have fractional size of 1 per cent or less this can be used as a representative size of the valley flat sub-system. In contrast, the representative size of the areas under the Bangar edge sub-system is more than 1 per cent of the total population of a tract.

The value of the mean increases to more than 400 persons if the fractional value is converted to the actual values and the poisson distribution approaches normal distribution as tested earlier (Table 4.1, Appendix C). However, the actual values are not comparable On the other hand, the fractional values are not only comparable but also easy to handle. A sample of the distribution of population in the Ganga Khadar tract is shown in Figure 4.1 for the extended series and in Figure 4.2 for the medium series. The Hindon lacks the valley flat clumps while the Yamuna has only five of them in Ghaziabad and the area covered is too small to be shown in the map.

The inferential statistics used so far hide the underlying *spatial trend* moving from channel to the Bangar or the *vice-versa*. The spatial trend can be studied by using the *regional mean* which is comparable to the index of crowding (Boyce).[3] Regional mean is the average population of a cluster of clumps assigned to a village at the centre. It is calculated by adding population of a village in the centre with the populations of all those villages which share the boundary with the village under calculation. Thus,

$$M(i) = \frac{T}{N} \quad i=1 \text{ to } N,$$

where

$M(i)$ is the regional mean calculated for the ith village as the centre ; T is the total population of the cluster of clumps sharing a common boundary ; and N is the number of villages in the cluster of clumps being added.

Table 4.3 of the Appendix C shows the calculation of the regional mean for the spatially contiguous villages in a section of

3. Boyce, R.B. and W.A.V. Clark (1964), *Ibid.* [The Concept of Shape in Geography, *Geogr. Rev.*,] 54, 561-572.

the extended series of the northern Ganga Khadar tract in Mawana. An average for each of the habitat zone is derived on the basis of these villages and is plotted in Figure 4.3 in the form of a *spatial trend line*. The average trend-line is sloping downward towards the channel. The observed trend line shows a lump at Kunhera (G-016) located along the Meerut-Bijnore highway. It represents a modified series. Slight rise in the trend line at Sherpur (G-020) is due to the fact that it is being affected by the receding meander while adjoining Parsapur (G-021) falls under the encroaching meander. The disparity in regional means with the habitat zones and Khadar series is given in Table 4.3, Appendix C. There is a remarkable drop of 251 persons as the size under VFS from 517 persons in BES of the extended series.

(*b*) **The Density.** The numerical distribution described above can be compared with the spatial distribution in multi dimensions. The dimensions used are length and width of the occupied area along with the counts of individuals in a clump. As such the spatial attribute of the area is used as a variable in the measurement of a clump size. There are two ways in which the spatial distribution is measured ; *i.e.*, as the arithmetic mean expressing the relationship between the gross area and the counts of individuals in contrast to the ecological density measuring the relationship between the resource area and the count of the individuals.

The arithmetic density is defined as the number of persons per unit area. The total population of a village is divided by the total area of the village. If all the areas had similar spatial attributes, density distribution would correspond with area distribution of villages (Chapter 2). However, in the case of Ganga about 50 per cent of the villages have the arithmetic density of less than 100 persons per square kilometre though area increases from about 100 square kilometre to more than 3,000 square kilometres. Barring a few exceptions the density along the Ganga stays below 300 persons per square kilometre. The density along the Yamuna in 47 per cent of the villages is between 300 persons to 500 persons per square kilometre and only in 13 per cent of the villages it falls to 100 persons or less. In case of the Hindon, 45 per cent of the villages have density greater than 100 persons per square kilometre, and only in 10 per cent cases it drops to less than 100 persons to equate with the Ganga. Thus, the Ganga dominated

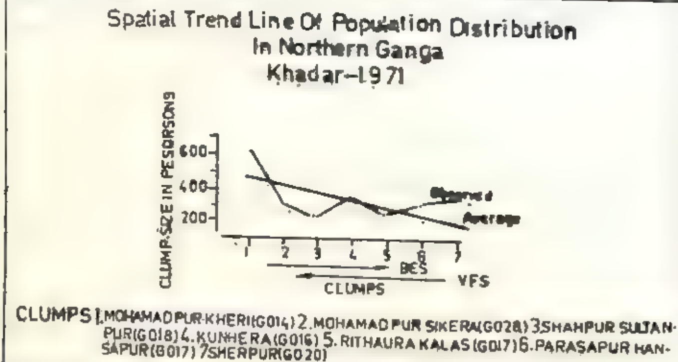


Fig-4.3

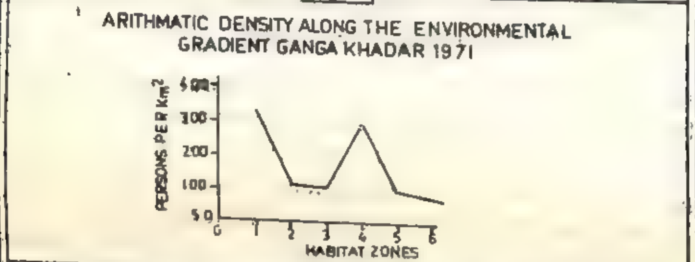


Fig-4.4

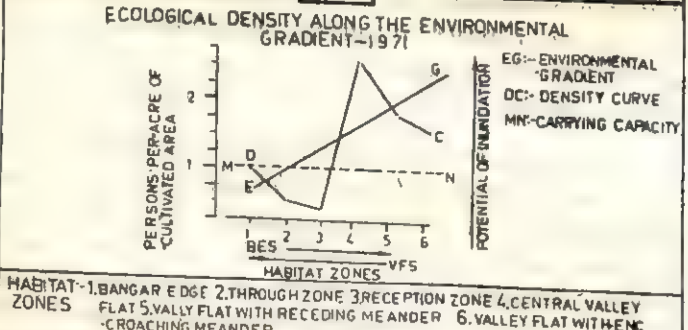


Fig-4.5

by the extended and medium series, is associated with low arithmetic density while the Yamuna dominated by the superimposed series and accompanied by a few of the villages of the medium series has higher density while the Hindon with exclusive composition of the superimposed series is dominated by high density and shows fewer fluctuations.

It may be recalled that the Khadar series are summarised from the habitat zones and the broad pattern of the arithmetic density

must show similar relationship. The correspondence of the two is examplified by the Ganga which has the representative villages from all the habitat zones. It is plotted in Figure 4.4 based on the averages of the each zone along the Ganga. As is clear from the illustration the arithmetic density declines to about one-fourth from the Bangar edge of the extended and medium series to the valley flat along the encroaching meander. Decline is rapid from the Bangar edge but shows a phenomenal increase at the central valley flat of the middle terrace running along the Mawana-Bijnore highway. The Yamuna and the Hindon lack the complete list of habitat zones hence the corresponding study of the two Khadar tracts is not presented here.

The use of gross area for analysing the arithmetic density is based on the assumption that the total village area is the area available for man's interactions. However, it is an empirically derived fact that man does not come to occupy a space and initiate ecological interactions, unless he can obtain the minimum of 0.25 acres of cultivated land per person as in 23 per cent of the villages which are now clumps of the Ganga Khadar tract. Man holds on to the space, and perpetuates the interactions, only when and where he can obtain about one acre of cultivated land per person as in 52 per cent of the villages with 1/2 to 1½ acres per person. The average size is termed the carrying capacity of land to support man for ecological interactions. The counts of the individuals may exceed or lower relative to the carrying capacity of land standardized as one acre of cultivated land per person.

The density of man measured with reference to the carrying capacity of land is the *ecological density*. It is expressed as the number of persons per acre of cultivated land. As stated above in about 52 per cent villages *the ecological density is about one person per acre of the cultivated land* but can more conveniently be expressed (or reversed) as acres per person. The density variations correspond with the habitat zone, as shown in Figure 4.5 plotted for the Ganga Khadar tract.

As shown in Figure 4.5 the ecological density is about one person per acre of cultivated land in the Bangar edge villages. The density lowers with increasing dominance of the Khadar processes

and decreasing share of the Bangar in BES. The trough zone, indicating the termination of the Bangar processes, has very low density where each person can have about 3 acres of the cultivated land. There are places such as Daulatpur or Malipur (G-032) where each person has 4.83 acres of cultivated land. The drop in density is more than compensated by increase in the VFS covered by the central valley flat of the Ganga. There is the average of about half an acre of land per person in this zone including places such as Manpur (G-005) with 0.06 acres and Latifpur (G-046) and Tarapur (G-008) with 0.18 acres. Thus, the density becomes double the average size of the villages of the BES under the superimposed series. There is slight decrease in density at the valley flat along the channel though is maintains the difference between the encroaching and receding meanders. Thus, Bela (G-001) with encroaching meander has only 0.18 acres per persons in contrast to Kharkali (G-086) further south which has 31.96 acres per person and Bhagwanpur Khadar (G-104) still further South with 54.37 acres of cultivated land per person.

Exceptionally low and high density can be explained partly with reference to the habitat processes and partly by other processes generated elsewhere but operating in the Khadar habitat. Meander sweep is the main process generated within the Khadar habitat operating as a control of the ecological density. Cultivated land is submerged under water as a meander encroaches towards a village settlement. There is loss of land but man continues to occupy the village due to inertia. This raises the ecological density as in the case of Bela mentioned above. It may be noticed that Bela was submerged and completely abandoned at the time of the field work about four years after the 1971 Census enumeration. As meander recedes from a village, land re-emerges from the water surface though soil may not be matured enough for cultivation. It may be recalled that such areas are dominated by natural vegetation, as mentioned in Chapter 3 (Figure 3.1.). Return of man to the emerging land is slow raising the ecological density to high figures as examplified by Kharkali. The village had started recovering from meander sweep in 1976 as reported by the local people contacted during the study of field work.

Exceptionally high and low ecological density can also be

generated by man-made cultural factors operating in the Khadar habitat. The effect is noticeable in the Khola zone and in the valley flat linked to some line of circulation *viz.*, a highway. Gully erosion can lead to total loss of cultivated land turning a village uninhabited. However, if some land is recovered, man may not return to the village as the area remains physically unapproachable due to deep ravines. Man lacks social and physical security and would not risk living in such areas. This keeps the ecological density low in the Khola zone *e.g.*, Saidullapur (G-100) with 59.33 acres of cultivated land per person. It may be noticed that the density had not changed even at the time of field work about four years later.

The contact of a highway has the reverse effect of raising the ecological density. It increases man's physical and social contact and can provide greater physical and social security. In some cases, small villages with less security are abandoned in favour of these road-link villages. This raises the ecological density of road-link villages at the cost of surrounding villages. Thus, Latifpur (G-046) along Mawana-Bijnore highway is surrounded by the number of uninhabited villages, *viz.*, Seemla (G-056), Khirjapur (G-051), Gokalpur (G-036), Dabkheri (G-018) and Rupra (G-022). It shelters man from the surrounding villages specially during inundation and has only 0.18 acres per person.

The effect of the highways is particularly noticeable in the Khola zone. Some of the Khola villages, *e.g.*, Asifabad (G-091) and Nimka (G-082) are linked to a large number of villages in the valley flat, as well as to villages and town of the Bangar. Man displaced by a meander sweep takes shelter at these villages raising the ecological density of these exceptional villages of the Khola zone. Asifabad and Nimka in Mawana command the adjoining valley flat of the extended series of the Ganga (Figure 4.1) from Aidalpur (G-080) in the North to Tarbiatpur Janubi (G-098) in the South. It raises the ecological density so that each person can have only 0.4922 acres in Asifabad and 0.4599 acres in Nimka.

The spatial variations in the ecological density can be graded along a habitat zones. It may be recalled that the arithmetic density and the regional means show similar gradation like the

Khadar biota (Chapter 3) also is graded along the habitat zones. The numbers of spatial units in Figure 4 3 are the grades of environmental gradient. The gradient is highest at the Bangar edge under BES and lowers towards the channel under VFS. It is inversely related to the potential of inundation shown by the inundation curve in Figure 4.5. The trend can be explained by the mechanism of population distribution.

3. THE MECHANISM OF DISTRIBUTION

The initial location of man and his subsequent aggregation forming a clump in space results from the mechanics of distribution *viz.*, dispersal. Man's psychological constraints contrasted with his mobility, enable him to disperse to any spatial segment of land that has provision of at least a moderate supply of water. Such segments are positive niches available for man's dispersal. They are surrounded by the negative areas with excess or deficiency of water under the valley flat and Bangar edge sub-systems.

The negative areas under VFS are those which have a natural water supply in excess of man's capacity to use. The excess and the ensuing negation, may be temporary or permanent. Temporary negative areas under VFS are associated with the meander sweeps and can also act in BES of the truncated series. Encroaching meander submerges at least a part of a village area rendering it useless for man's occupation. Makhdumpur (G-062) in Figure 4.2 is such an example. Land emerges back after the meander starts receding and is available for man's occupation once again. Permanent negative areas under VFS are associated with stagnating water. It is a prevalent attribute of the trough zone but pools of stagnant water can occur at the valley flat depressions. Some of these depressions may be shallow enough to dry up at least for a brief summer period, while others may remain partially wet even during summers resulting either from greater depth of depression or from high water table or both.

The negative areas under BES are those suffering from the physiological drought (Chapter 3). Most of the land is covered by excessive slope and water drains off rapidly before it can be used by man as well as by plants. Water table drops so low that

water cannot be lifted manually from the sub-surface. Surface water bodies are lacking. Some areas may contain a natural or man-made drain but water surface is too low to be used conveniently by man. These areas remain negative as long as the attribute of space in terms of water remains unchanged. Kiratpur (G-098), Badshahpur (G-099) and Ibrahimpur (G-101) in Figure 4.1 are examples of such negative areas of the Khola zone.

The list of the negative areas is given as uninhabited villages in Appendix C, Table 4.4. As is apparent most of the negative areas are located in the trough and Khola zones (shown by zero clump size in Figure 4.1). There are not many temporary uninhabited villages along the channel as these negative areas are temporary. On the whole, uninhabited villages are fewer along the Yamuna where Khadar tract is less developed. The number is even smaller along the Hindon where the Khadar has a very limited development.

The rhythmic occurrence of the negative areas is the integral part of Khadar eco-system. However, there are some perceived negative areas which lack the attributes associated with the negative areas in the Khadar environment, yet remain uninhabited. These areas may have developed the negative attribute at some time but man did not revert to its occupation even after the spatial attributes had changed. Thus, Khandwari (Y-023) North of Baghpat along the Yamuna, and Sikari (H-027) in Meerut along the Hindon also fall in this category. On the other hand, there may be human clumps located in the negative areas, specially where deep gullies penetrate almost into the dwellings of man. These are the anomalies in the negative areas forming a reminiscent settlement Chapter 6).

The negative areas located anywhere form a small pocket in an otherwise contiguous positive niches available for the location of a clump of man. A Khadar tract may be viewed as a collection of an infinitesmal number of the positive niches though only very few of these niches are actually occupied by the clumps. As such location of the occupied positive niches would have the poisson probability distribution and the ensuing spatial pattern

can be analysed as the *R-index* of the nearest neighbour (Clark and Evans).[4] The index for the Ganga tract is 1.005 indicating a random distribution. The corresponding work for the Yamuna and the Hindon is of little significance as most of the nearest neighbours are located either deep in the Bangar or across the channel. These are relatively dry niches under VFS as is clear from the abundance of clumps at the middle terrace in Figure 4.1. No such apparent link is visible on the map for the clumps in the BES.

The chosen positive niche results partly for the factor of dispersal and partly from the mechanism of behaviour. As a biological species man's behaviour is adjustable to the attribute of water as prevails in the Khadar. Individuals aggregating as a clump must adjust to the periodic inundation of land otherwise involuntarily be moved out by better adjusting man through competition.

The competition for choosing a positive niche occurs among the undifferentiated member individuals of a clump. It acts as economic or social stress. Economic stress is also called population pressure. A clump size may be too big to be supported by local availability of the resources. The individuals, or the families, lacking support of any local resource, *e.g.*, agricultural land, move out under competition of those who own some local resources. Some of the individuals may move out to be able to have the resource size larger than they possess or to substitute their resources with others. In most of the cases the presence of local resources is responsible for the initial location of an individual and his subsequent aggregation as a clump. The stress may be responsible for continued expansion of a clump. Thus, many inhabitants of Kishanpur Khadar (G-035), Manpur (G-005), Fazalpur (G-009) and the surrounding areas were initially settled as institutional persons (Census 1951) who were landless refugees from the erstwhile West Punjab. The result of the present economic stress can be traced in Rampur or Niamatipur (G-130) where migrants from the Punjab and Delhi have

4. Clark, P.J. and Evans, F.C. (1954), Distance to Nearest Neighbour as a Measure of Spatial Relationships in Populations, *Ecology*, 35, 445-453.

recently settled after the original *Mallahs* of the village sold off their land to others. Saidullapur (G-100) and Kiritpur (G-098) which appear as new clumps (Figure 4.1) in 1971 Census, are inhabited by individuals seeking argicultural land which they lacked elsewhere.

The competition as social stress may act in the initial or subsequent years. Many Harijans in VFS of the Ganga and the Yamuna must have initially moved to these areas under social stress of untouchability. Many Brahmins of the area must also have occupied the area under social stress, seeking lonely place for meditation. This has resulted in villages such as, Illaichipur (Y-045) along the Yamuna and Manoharpur (G-042) along the Ganga as the exclusive Harijan villages, to quote only a few cases, while Kutubpur (G-114) along the Ganga remains an exclusive villages of the Brahmins. Caste preferences continue to play a role in the distribution of man even in later years. Thus, Bagwala or Tarbiatpur Janubi (G-095) in VFS of Mawana sheltered two Saini families from the neighbouring Tarbiatpur Shumali (G-088) when the latter was largely submerged by the meander encroachment of the Ganga in 1975.

The competition may also appears as a political stress, Thus, Bhadwi (G-044) in VFS of the Ganga has been settled by the refugees from Bangladesh under some policy of the administration. It appears as a new village in 1971 Census.

The competition goes along with symbiosis. The individual members of a population clump benefit each other through their interactions (Community Organisation, Chapter 5). There is also certain degree of symbiosis between the biota and man's population. Man's population interacts with the environment in such a way as to modify the natural vegetation of the area maintaining a limit of modification (Chapter 3). The environmental variables would be completely altered in the absence of such a limit and the related eco-system would terminate.

4. THE DYNAMICS OF POPULATION

The individuals of a clump multiply with time so that the population grows in size. While the number of births add to the

population, death has a punitive effect. The balance of the two gives the natural growth of population. It can be modified by the factor of migration. The growth of population is the combined effect of the two factors and is studied as the dynamics of the population change. The two factors can be studied separately.

(*a*) **Natural Growth.** The natural growth is the difference between births and deaths at a time and place. Time units are used as the denominator to obtain the growth rate per year. Growth is dependent on some population parameters. The fundamental population parameter is the sex composition. It is expressed as female-male ratio of a population. It is nearly a constant in space and time. There is the average of 46 females in a population of 100 persons based on the 1971 Census.

The slight deviation from the average pattern is corrected in a short period of time except in two cases. The marked deviation in female ratio can occur in areas where a clump is beginning to be formed, identified as an uninhabited village in the previous census year and having a very small clump size. Thus, Saildullapur (G-100) has no female in a total population of 3 persons. It appears as a new village in 1971 Census (Figure 4.1), being uninhabited in the previous census. So is the case at Ropra (G-022) with 2 persons, Kutubpur (G-114) with 5 persons and Aidalpur or Parshadipur (G-120) with 14 persons. Some, like Ropra and Aidalpur, are located in the valley flat sub-system, while the others are located in the Khola zone of the Bangar edge sub-system. Even when a small clump contains some females, the ratio is very low. Thus, Bhagwanpur Khadar (G-112) is a new clump with 12 per cent females in total population of 8 persons. A small change in numbers can tilt the balance as Jalalpur Raunkali (G-012) near Hastinapur which has 53 per cent females in total population of 15 persons and Bhadwi (G-044) with 50.99 per cent females in total population of 151 persons.

The sex composition affects the natural growth through the age structure. It describes the size of population in each sex at different age levels. In the absence of the Census data at a village

level, age structure and the subsequent population parameters are based on the field study of the sample villages from the three Khadar tracts. Age years are grouped to compute many other population parameters which are expressed in the form of life tables (Lotka).[5] The life tables for some of the sampled villages of the three Khadar tracts is given in Appendix C, Table 4.5.

The first computed parameter in the life tables is lx. or, the *numbers of females surviving at start of age interval x*. Numbers in the first age groups are taken as *l*. This column is used most frequently in life-table. The lx column is actually the probability column such as the probability that an individual at age x will live an additional h years, is

$$Pr(\text{alive at } x+h/\text{alive at } x) = \frac{Pr(\text{alive at } x+h \text{ and at } x)}{Pr(\text{alive at } x)}$$

$$= \frac{Pr(\text{alive at } x+h)}{Pr(\text{alive at } x)}$$

$$lx = \frac{P(x+h)}{1(x)} = hp(x)$$

The lx columns show that the size of the female population is maximum in the age group of 10-12 years in the sampled villages. It is low in the early categories as female infant mortality is high; the size declines after 10-12 years of age as well. Reduction in size is by way of marriage and exodus from the village. This is some what compensated around the age group of 15 years when brides arrive from other villages. Numbers decline constantly thereafter.

The female numbers and the lx columns makes it clear that the females born at the valley flat are married off at an early age. The male counter parts are married at later ages, therefore, there is a gap between the exodus and the arrival through marriages. This was remarkably so in Hadipur (G-040) which was in the process of rehabilitation after being washed away by meander encroachment in 1976. Outside the valley flat sub-system

5. Lotka, A.J., 1907, Studies on the Mode of Growth of Material Aggregates, *Amer. J. Sci.*, 24, 199-216.

disparity among the outgoing and incoming brides was not noticed.

The next parameter in the life tables is the birth by age of mothers, or the age specific birth rates' *mx*. The significant feature of *mx* in these life tables is the very early reproductive age of women in the sampled villages. In some villages of the valley flat sub-system women reportedly started reproducing at the age of twelve years. The reproductive period continues to be about fifty five years of age. Early reproductive age is not common outside the valley flat sub-system. Thus the Yamuna tract has only one such case, the Hindon has none.

Birth by age of mothers forms a small rate in the initial age groups. It increases to the maximum around the age group of thirty years and declines thereafter. Not very many procreate till the age of 45 years, but those who do normally have a high reproductive value.

The age specific birth rate shows a different trend around Delhi. It is dominated by the schedule castes. Reproduction begins at later age resulting from slightly late marriages. The total number of children are also fewer than elsewhere. Thus, *mx* values are confined to the age groups between 20 to 40 years and the values are low. This trend is associated with the urban influence of Delhi.

It is conventional to derive mean expectation of life, *ex*, at the start of age *x′*, from *lx* and *mx* as the *average expectation of life*, such as

$$ex = \frac{T_x}{L_x}$$

where,

$$Tx = \sum_{i=1}^{\infty} Lx/\text{and } \; Lx = \frac{(1x)+(x+1)}{1}$$

The *ex* values for each age group are calculated for each sample village. In all the sampled cases it was found that the mean expectation of further life is maximum in the age groups of 20 to 40

years and low in earlier and later years. Mean expectation is generally low at the valley flat and increases at the Bangar edge.

Analogous to the ex-values is the *survivorship curve*. It can be drawn straight from the *lx*-values. There are three types of hypothetical curves. Type I has relatively uniform number of survivors till the later age groups. Number of survivors end abruptly at the end of age groups (Kakor and Ilaichipur in Figure 4.6). This type of curve is not common in the Khadar areas. Type II curve has steep but uniformly declining number of survivors with increasing age. This type of curve is typical of the Yamuna and the Hindon Khadar (Goripur and Khanpur in Figure 4.6). It indicates a constant rate of mortality independent of age. Type III curve is most common of the Khadars of the Yamuna and the Ganga. The only exceptions are Kharkali (G-086), Jalalpur Zora (G-041) and Mirzapur (G-078). The curve is L-shaped (Subhanpur and Mirpur Sadho Nagla in Figure 4.6) and indicates high loss in early life, followed by a period of lower and relatively constant losses. It follows the period through and immediately after an meander encroachment. The curve flattens out at the age group of 20 years or so.

There are some population parameters which are derived from the above mentioned variable. One of them is the *net reproductive value* or, *Ro*. The *Ro* value describes the mean number of off-springs per female. This is derived from the actual age and sex distribution of the population. Thus,

$$Ro = (lx)\,(Yx) = \sum_{i=1}^{\infty} Vx$$

where $Vx = (lx)\,(Mx)$; *lx*, *Mx*, values being the same as before.

The net reproductive rate in the VFS along channel is four increasing to seven at other places. The net reproductive rate ranges between seven and nine off-springs in the Bangar edge sub-system where the Khadar environment is the least. This is common for the superimposed and the truncated series, *e g*., at Goripur (Y-020) and Kheri Padhan (Y-012).

The villages along the Hindon have a medium value of *Ro*. They represent the superimposed series and have the additional feature of being well connected to a large number of towns, *e.g.*, Ghaziabad, Moradnagar, Modinagar, Baghpat, Baraut, Sardhana, and Meerut (Figure 1.1). The urban influence has already been described in context of *mx* values. It indicates that urban environment modifies the environment as the modified interrupted Khadar (Laliana Rampur or Niamatipur in Figure 4.6).

Ro value is used for computing another population parameter, *G*. This is the *mean length of generation* or *mean gestation i.e.*,

$$G = \frac{(x)\,(lx)\,(mx)}{(lx)\,(mx)} = \frac{(lx)\,(mx)\,(x)}{Ro}$$

G values describe the average period that lapses between the age of mothers and daughters when they start reproducing. Mean generation length is less than 30 years in the VFS of the valley flat along channel and higher elsewhere.

The *Ro* value and the *G* value are used to compute the value of the *innate capacity to increase or the intrinsic rate of natural increase, i.e., Rm*. This rate is the net effect of given environmental conditions. Thus, each village would have its own *Rm* value.

The parameter *Rm*

$$= \frac{\log e\,(Ro)}{G}$$

Because the generation time, *G*, is an approximate estimate, the value of *Rm* also is an approximate estimate when the generations overlap.

The innate capacity for increase can be determined more accurately by solving the formula derived by Lotka (1907, 1913).[6]

$$\sum_{x=0}^{\infty} e^{-Rm\,(x)}\,(lx)\,(mx) = 1$$

6. *Ibid.*

By substituting the trial values of *Rm*, the actual value of *Rm* can be simulated. Usually the simulated and the estimated values of *Rm* are not very different from each other (Krebs).[7] It is observed that the *Rm*-value is lowest, *i.e.*, less than .04, at the valley flat along channel, but increases towards the Bangar. At the Bangar edge it tends to be greater than 0.05.

The caste also is associated with the *Rm* parameter. Low *Rm* values at Subhanpur (H-040) and Sothari (H-041) along the Hindon may be associated with the schedule caste even though they are part of the modified series.

The *Rm* value is used for computing a theoretical distribution of age and sex, called the *stable age distribution*. This distribution shows the proportion of population in an age group if population were changed at a relatively constant rate.

The computation of the stable age distribution involves the use of the intrinsic rate of the population growth, *i.e.*, *Rm*, particular of the given enviroment. Basic assumption behind the stable age theory is that population in these areas grows at a geometric rate, *i.e.*, while the size increases rapidly rate of growth increases only slowly.

Stable age distribution is defined as

Cx = proportion of organisms in the age category x to $x+1$ in a population increasing geometrically.

Mertz (1970)[8] has shown that

$$C_{x}=\frac{\lambda^{-x}\, lx}{\sum\limits_{i=0}^{\infty} \lambda^{-i}\, li}$$

7. Krebs, *Ibid.*,
8. Mertz, D.B., 1970, Notes on Methods Used in Life History Studies, pp. 4-17 in *Readings in Ecology and Ecologied Genetics*, ed. by J.H. Connell, D.B. Mertz, and W.W. Murdoch, Harper & Row, New York.

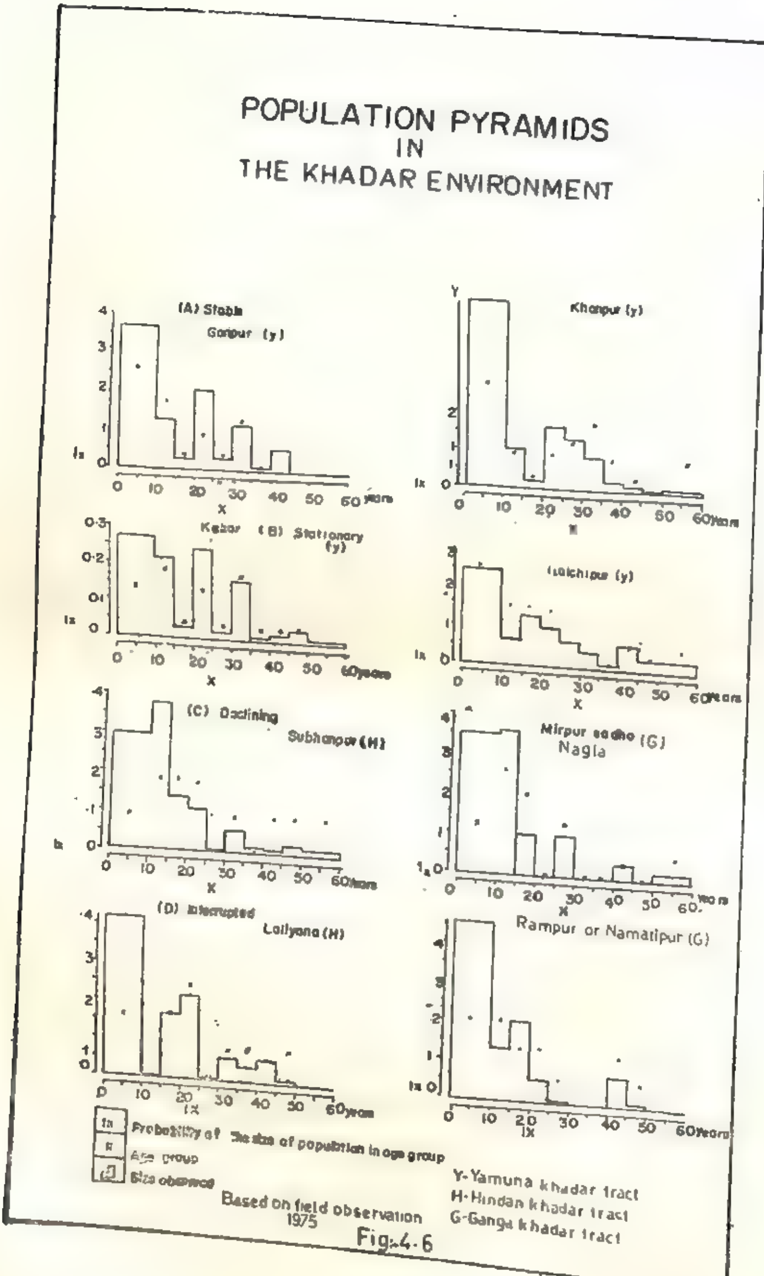

POPULATION PYRAMIDS IN THE KHADAR ENVIRONMENT
(A) Stable
Goripur (y)
Khanpur (y)
Kazor (B) Stationary (y)
Lalchipur (y)
(C) Declining
Subhanpur (H)
Mirpur sadho (G)
Nagla
(D) Interrupted
Lallyana (H)
Rampur or Namatipur (G)
lx Probability of the size of population in age group
x Age group
Size observed
Based on field observation 1975
Y-Yamuna khadar tract
H-Hindan khadar tract
G-Ganga khadar tract

Fig. 4.6

where

$\lambda = eRm$ = finite rate of increase,

lx = survivorship function from life table,

x, i = subscripts indicating age.

The Cx is calculated for each age group for all the sample villages of the three Khadars. This theoretical distribution $Cx\ (i)$ is plotted against the actual lx values. It is shown as the population pyramids in Figure 4.6. Sampled from the three Khadar tracts, the pyramids represent the four types of population growth. Stable populations are ever-expanding and are common under BES as at Goripur (Y-020) and Khanpur (Y-014). The stationary populations have a negligible rate of growth, and prevail at Bangar edge being eroded by the channel at Kakor (Y-007) and Ilaichipur (Y-045). Rigorous encroachment by channel at the Bangar edge or the valley flat results is declining populations as at Subhanpur (H-040) and Mirpur Sadho Nagla (G-085). Interrupted pyramids are partly the result of meander sweep and also partly of the urban influence under migration factor as at Laliyana (H-037) and Rampur or Niamatipur (G-130).

(*b*) **Migration.** The migration from the Bangar edge to the valley flat is responsible for the initial inhabitation of the flat. It is initiated when the flat is widened enough to accommodate a settlement. The process can also be reversed by meander encroachment under some conditions, *e.g.*, when a village is getting submerged, a clump is abandoned. Population moves out to the safer places and such villages show 100 per cent decline (*D* in Figures 4.1 and 4.2).

The village which receives refugees from one or some such villages, shows exceptionally high growth rate in an area of the small growth rate or declining growth. When conditions improve in the next few following years, some or all the inhabitants may return to the old abandoned village, creating a new village (*N* in Figures 4.1 and 4.2) in VFS. The out migration from the flood hit area is more than the return migration. This hypothesis is incorporated in the census records.

The field observations revealed that the migrating persons show caste preferences in choosing a shelter village. Some families from the submerged villages settle down in a neighbouring village having the population of its own caste. For example, Tarbiatpur Shumali (G-088) was washed off in 1975 rains. The Saini of the village joined the Saini Community of Bagwala or Tarbiatpur Janubi (G-095). The Harijans of the ill-fated village joined the harijan *majara* (hamlet) of Rambha Nadallipur or Bagwala (Figure 4.1). Others went over to Asifabad (G-091) or other Kholas. Similar caste preferences were shown by the families dispersing from the river hit villages of Mirpur Sadho Nagla (G-085) and Kharkali (G-086) located further North in Mawana.

The return migration from the Kholas shows a definite pattern. Some individuals from the Bangar return to their own land as soon as their land re-emerges from water. As land emerges slowly return-migration is low. Meanwhile, many owners are not able to wait so they sell off their land and move out from the Khadar habitat. The buyers form the return migration. At times these new migrants may be more in numbers than the original inhabitants. A village may be baptised with a new name. Multi-named villages are common along a channel whether in VFS or in BES.

The return migration from the neighbouring villages of the valley flat may be smaller and slower than from the Bangar. These families may continue to live in their new village for ever, or at least till the time their new village is also damaged somehow. They probably get a sense of stronger community feeling, hence continue to live there while they can as conveniently or inconveniently cultivate their land from the present village as from the previous village. Thus, Gujar village of Mahumdabad (G-089) had a family of Gujars from Kharkali (G-086). The settlement of Kharkali was damaged in early 1970 when all the villagers left for the neighbouring villages. When the river receded, the dominant community of the Harijans returned to a new site at Kharkali, people of other caste stayed back. There are such large number of villages near Bhikund or Rustampur (G-045), *viz.*, Kishanpur (G-035), Ropra (G-022), Jalalpur Maqbolpur (G-049) and Paharpur Qutub (G-050) with Sikh *khatris* alone.

A distinct *growth pattern* emerges on the basis of the two growth factors of the natural growth and migration. It can be measured based on the numbers alone. Thus, the growth of a population, *N*, at a time, $To+1$, is the difference, *Nd*, in its size, *n*, between the time *To* and $To+1$. The difference is converted to a fraction of the size of population at the initial time, *To*, to make the two figures comparable. This is called the relative growth. It has been plotted in Figure 4.7 for the three Khadar tracts for the years 1961-71.

The three Khadar tracts show definite trends (Figure 4.7). In most of the villages the relative change of population (1971-1961)/61 shows an increase between 20 per cent to 30 per cent per decade in the three census decades. The average growth rate is 25 per cent per decade. The curves show a break at mid-point of 55 per cent. In 94 per cent of the villages of the Hindon tract, the relative growth has been less than 60 per cent between 1961-71. The corresponding figures for the Yamuna and the Ganga are 75 per cent and 67 per cent. It may be recalled that some villages along the Hindon have very big size of population. The size is less frequent along the Yamuna and the least along the Ganga. It can be concluded that when the size of population becomes larger the growth rate becomes lower, and the *vice-versa*. The correlation between the two variables for the Ganga, Yamuna and the Hindon tracts show the coefficient values of —0.68, —0.65 and —0.68 respectively. The trend of decreasing rate with increasing size is called the *Allee's principle* (Allee *et al.*, 1949).[9]

The Figure 4.7 also reveals that there are large number of villages with hundred per cent growth, or decline. They are located at the valley flat along the Ganga channel associated with the natural economic or other stresses mentioned above. The attribute is less marked in the Census decade of 1971-61 than in 1961-51. The decline of 100 per cent shows depopulation or abandoning of a village while 100 per cent increase shows appearance of a new clump. New clumps are uninhabited in the previous census year (*N* in Figures 4.1 and 4.2). They are also

9. Allee, W.C. ; Emerson. A.E , Park, O. ; Park, T ; and Schmidt, K..1P9 4.9 *Principles of Animal Ecology*. Sanders, Philadelphia.

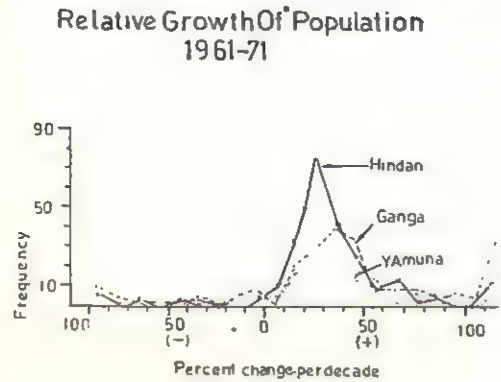


Fig-4.7

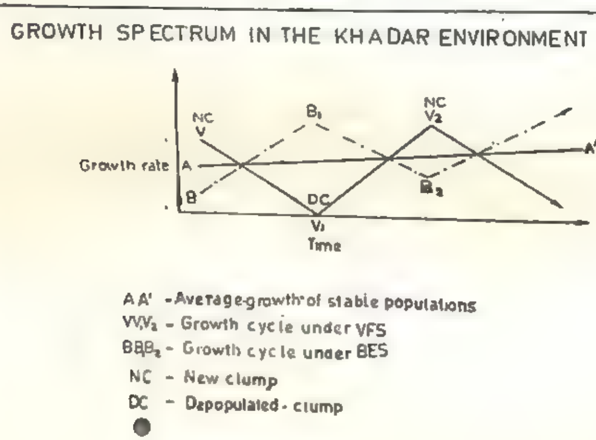


Fig-4.8

marked by small size of the clump. Common fractional size is less than 0.1 per cent of the total population of a tract. Nearly all of them are located in VFS, specially along the channel (Table 4.4 in Appendix C) while a few of them occupy the Khola zone of BES (Figure 4.2 and Table 4.4). Accompanying the new clumps are those which have phenomenal rates of increase or decrease in the clump size. Thus, Latifpur (G-046), Asifabad (G-091), Nimka (G-082) and Agwanpur (G-081) are some of the villages with very high rates of increase or decrease during the Census decades of

1951-61 and 1961-71 along with host of new or abandoned villages as shown in Table 4.4.

The marked deviations in growth rates create the phenomenon of *shelter village* as an attribute of population in the Khadar environment. These are the villages which shelter man from the surrounding areas, providing safety either from meander encroachment or any other environmental variable. They are marked by more than the average increase in the growth rate and may be followed by similar decrease in another year. Increase and decrease depends on the timings of a meander encroachment and the recession and may not correspond to a census year, therefore, the statistical evidence from the census cannot be provided.

The occurrence of a shelter village at any time may show a spatial shift downstream as meanders move downstream. These villages have the supporting attribute of high ecological density caused by the individuals aggregating from the neighbouring areas of a meander encroachment while its own size of the cultivated area remains unchanged. There is a similar increase in the arithmetic density. The clump size of the shelter village may be larger than the average of the surrounding area.

As an example, Latifpur (G-046) acted as a shelter village during 1971 Census. The clump size is recorded as 1970 persons against the average of 241 persons in the VES of the Ganga. It has arithmetic density of about 833 persons per square kilometre and ecological density of 0.180 acres per petson against the average arithmetic density of 241 persons/square kilometres and average ecological density of one person per acre. Its total population changed from 1,469 persons in 1961 to 1,940 persons in 1971 showing the growth rate of +32 per cent per decade against the average of 25 per cent.

The shelter villages are generally located at places having easy connectivity with the areas needing shelter and are essentially safer from the threatening havoc of inundation than the villages seeking shelter. When the threat is posed by a meander encroachment, safety is provided by the villages in BES. Caste

preference may also be a factor in choosing a village for shelter, though the number of persons seeking shelter in a village on the basis of caste is always very small. The caste based migration to a shelter village does not affect the growth and density pattern of the shelter village.

5. THE CONCLUSION

The population of man as an environmental variable is a cluster of individuals aggregated as a clump at some chosen spatial scale. Scale can be local, confined to a census village and environmental, representing the summary or aggregate from the census villages stretched over all the spatial segments within the environment. A clump, at any chosen scale, has the variable attribute of size measured in one or more dimensions.

Measurement of clump size in one dimension yields the average size of 250 persons in the valley flat sub-system of the Ganga representing the extended series while the VFS of the Yamuna representing the *medium series has the average size of 500 persons.* The *Bangar edge sub-system* has larger size, *being greater than 1,000 persons* in the superimposed series of the Hindan and the Yamuna, though the truncated series has small size of 370 persons only. Absolute size can also be measured as regional means (Figure 4.3) which is the trend analysis of the size, moved over space. Regional means and the average size distribution corresponds to the environmental gradient evolved in the previous chapters.

Measured in more than one dimension, clump is the variable of ecological density expressed as the numbers of persons per unit area of cultivated land. *Average ecological density at environment level is one person per acre of cultivated land though it fluctuates widely at the village* level. The density is higher in villages under BES with less than half an acre of the cultivated land. They give shelter to man located in villages of the encroaching meander. The place of refugee is a shelter village, located often in the Khola zone of the BES but occasionally in the central valley flat of the VFS. Correspondingly, the ecological density of the villages with encroaching meander, generally located

in VFS, is very low so that one person tends to have more than ten acres of cultivated land.

The variable of clump size at any chosen scale changes through the process of natural growth and migration factor. The parameters of natural growth, *e.g.*, sex composition and age structure, are expressed in the life tables, as in the case of the sampled villages along the three Khadar tracts. The salient features of the life tables is that the *average number of offsprings per female in the VFS of the Ganga is four, but seven along the Hindon and nine along the Yamuna. This brings the average in Khadar environment to seven persons* The family size and the other population parameters are such that most of the villages show stable population growth marked by the *average increase of 25 per cent per annum* (*AA'* in Figure 4.8). The growth rate decrease to zero at V' in the villages along the channel operated by the VFS, followed by a rise in the growth rate to infinity with the formation of a new clump at V_2 after the meander starts receding. The changes in the growth rates are absorbed by an accelerated growth rate at the shelter village when a valley flat village undergoes a decline followed by a rapid fall in the growth rate of the shelter villages with the return of the refugees (B_2 in Fig. 4.8).

The attributes of population clump studied at the village level can be used to summarise at the environmental level assuming that the environment itself is an aggregate of villages A section of the environment is a slice of a Khadar tract extending from the VFS along the channel to BES in the Bangar. The size and density variations of the clump at the environmental level are shown in Figure 4.4. Simultaneous spatial changes in the growth rates are shown as *growth spectrum* in Figure 4.8. The spectrum combines the counter current of *growth rates located in different spatial segments of the environment though occupying a common temporal unit.*

The growth spectrum of population clump expresses the environmental variable of man as population system (Figure 4.8). The system is composed of the variable of clump size, V, V_1, V_2 and B, B_1, B_2 in Figure 4.8 measured in terms of the numbers or

density. The variable of clump size in turn is composed of the natural growth and migration factors as two sub-systerms related to each other through feedback relationship. The energy input for running the population system is provided by the carrying capacity of land that combines the out habitat and biotics systems so that the modified plant communities over the cultivated area of the habitat provide the capacity and the initial attraction for the location of man and his subsequent aggregation into a clump. This capacity is the *carrying capacity* of land expressed as prevalent ecological density of one person per acre of the cultivated land at environmental level though there can be wide fluctuations at village level.

The output of the population system is the variations in the degree of crowding at a clump with respect to ecological density. The system can produce a balanced ecological density or have *over-crowding so that there is less than one acre of cultivated land per person*, *e.g.*, in the shelter villages. There can be the output of *under-crowding so that a village*, *viz.*, those with meander encroachment *has more than one acre of land per person*. The output of population system affects the input through the feedback system to that carrying capacity also increases with increasing clump size. This is apparent from the fact that size of the cultivated areas remains more or less constant while the clump size has always been increasing. Thus, *AA′* in Figure 4.8 represents the variable input of carrying capacity increasing with time, just as it represents the variable of man at population level, measured at the environmental level. The output shows large fluctuations under the urban influence along the highways.

5

Man at Community Level of Organisation in the Khadar Environment

1. THE INTRODUCTION

The individuals aggregating in human clumps are grouped into the classes according to some differentiating attributes. The classes are populations. The populations can have a degree of inter-dependence and share a common territory forming a community at an arbitrarily chosen spatial scale. This chapter includes a human community as a variable in the Khadar system. It can operate at three spatial scales, *viz.*, organismic, operating at family level ; local, operating at village level ; and environmental, operating at the environmental level. The populations in a community, at any chosen scale have their own attributes. A community is structured with different populations. The interdependence among some populations sets the functioning of a community. The changes in the structural components and the ensuing relationships form the dynamics of the community organisation. The conclusion summarises the community organisation as a system.

2. THE STRUCTURE OF COMMUNITIES

The communities are structured with the apparent and general populations. Apparent similarity among individuals is used to group them into apparent populations. As such, a community is treated as the universe (Harvey)[1] composed of the apparent popula-

1. Harvey, *ibid.*

tions. The structural relationships among the individuals or their groups is used to divide an aggregate logically into the general populations. As such, a community is a genus (Chorley and Hagget)[2] divided into genera of populations, *i.e.*, general populations.

(*a*) *The apparent populations* are the aggregates of individuals with similar attributes which are perceived as the integral part of individuals and are considered irreversible, *i.e.*, once attained the attributes cannot be changed in the life time of an individual without disturbing his social set-up. These attributes are largely inherited though they may also be acquired. Three differentiating attributes are used to group individuals into the apparent populations. These are the attributes of religion, caste and literacy.

Religion is a strong differentiating attribute as perceived by man. Individuals of the same religion are aggregated as a single category of population. The prevailing population of the three Khadar tracts is composed of the Hindus. They form mono-population communities at village level in most of the cases though there are villages like Sarangpur (G-109) with Muslims alone, Mamipur (G-064) with neo-Buddhists alone and Kishanpur Khadar, (G-035) with Sikhs alone located in the VFS of the Ganga. There are few cases of multi-populations of different religions located in the areas under VFS, such as in Rampur or Niamatipur (G-130) along the Ganga. The diversity is associated with the recent migrants in the VFS of the Ganga.

The pattern changes in the BES where about 25 per cent of the observed cases have a diverse community of different religions.[3] Most of the communities are dominated by the Hindus who form more than 50 per cent of the total households in a village. Sub-dominant or the dorment populations are formed of the Muslims or the Sikhs. In some cases, such as at Asilpur (G-108), all the populations may be equally large in size. In the cases where the Hindu and non-Hindu clumps are nearly equally large in size, population of each religion is spatially segregated within a common village territory. Such a segregation is not conspicuous in the VFS.

2. Chorley and Hagget, *ibid.*
3 Based on the field observation.

The caste is generally perceived as a strong differentiating attribute among individuals. The families as well as the villages under the VFS are generally monocaste populations while the villages under the BES may have multiple-caste populations On the environment scale, a Khadar community is structured with multi-populations of the various castes. Jats, Thakurs, Yadavs, Tyagis and Brahmins or high castes in general, dominate the BES while the Harijans or Scheduled Castes populations are more prevalent under the VFS. Some of the caste-based populations may have strong social interactions as symbiosis or competition but, the relationship cannot be generalised for all the caste based populations. Moreover, the same caste does not show similar set of relationships everywhere. The relationship among the caste-based populations is more economic than social and arises due to the nature of work of the member individuals, for example, the relationship between land-owner cultivators and landless agricultural labourers. The landless labourer may be Brahmin or a Harijan and has certain common relationship with his master landlord irrespective of the caste.

The caste based population of the Harijans has a special place in the community structure associated with its spatial organisation. The Harijan populations are more wide spread in the VFS than in the BES. So much so that many census villages with large area under the BES have a separate cluster of Harijan population located as a satellite hamlet in the area under the VFS. Elsewhere the Harijans may have limited spatial segregation occupying the outer part of a village. Such a segregation is generally associated with the economic interdependence though it may be purely incidental or resulting from the caste differences. Where such a segregation is absent, the Harijans do not show economic interdependence either among themselves or with other caste-based populations as long as the nature of work of all the populations remains undifferentiated. Thus, *caste-based populations are perceived structural components of a community organisation but lack the required functional interdependence.*

The apparent populations of the literates and the illiterates are formed using literacy as the dividing principle. Literacy refers to the ability of an individual to read or write. A literate is one

who can read or write.[4] This is a partially acquired characteristic. An individual can move from an illiterate to a literate population but not in the reverse direction. The educational level attained by an individual is irrelevant.

A literate population is generally much smaller than an illiterate population with the ratio of 1 : 9.[5] The average fractional size of the literates is 0.14 of the total population in a village clump. It is used as a yard-stick for measuring the size of the two populations. The fractional size of the literate populations has a negatively skewed distribution so that 0.05, *i.e.*, 1/3rd of the average size indicates small size of the literate population while the fraction of 0.25 *i.e.*, about two times the mean, indicates the large size. The large size literate populations are very widely separated. They are occasionally contiguous with one or two villages of the medium size of the literate populations. Barring these patches the small size literate populations are dispersed everywhere at village level. The spread of literate population appears to grow with spatial diffusion. It is unrelated to the location of educational institutions or the habitat sub-systems of the VFS and BES. Thus, the literate population on Alipur Morna (G-068) in the BES of the Ganga is 0.06 of the total population despite the location of a junior and a senior school in the village in contrast with Manpur (G-005) in the VFS of the Ganga where the fractional size of literate population is 0.47 with only a primary school.

The spatial pattern of literate population shows little variations at different spatial scales. *Children of a family tend to be literate where at least one of the parent is literate.*[6] Literacy can spread to the neighbouring family of social similarities. The spread is faster among the families with urban contacts, *e.g.*, in the case of the migrants from the erstwhile West Punjab settled around Latifpur (G-046) in the VFS of the Ganga Khadar and the recent migrants from Delhi settled at Rampur or Niamatipur (G-130) in the VFS further South. The process of the diffusion of literacy is slow as urban contacts are few in the Khadar tracts. Thus, the distribution of literate populations shows little associa-

4. Based on the definition provided by the Census of India.
5. Based on *Village and Town Directory*, Meerut District, 1971.
6. Based on field observation.

tion with the environmental elements of the eco-system. Moreover, these populations have little mutual interdependence hence have no place in the functional organisation of the communities like the other apparent populations.

All the above mentioned apparent populations lack interdependence that can be associated with the intrinsic nature of the classes derived through the synthetic grouping of individuals into a universe of community. On the other hand, the community members are mutually dependent when treated as a genus and logically divided into genera of the general populations.

(*b*) *The general populations*, unlike the apparent populations, show a degree of interdependence of some sort and are divided into non-workers and workers. The division is based on the presence or absence of a gainful employment. A non-working population lacks a gainful employment while a working population is employed gainfully in the varying nature of work. The latter category of general population functions to run the community organisation through a set of inter-relationships, hence it is a set of functional populations. The individual members of general populations can have attributes which are acquired through the nature of the gainful employment. The attributes can change in the life time of an individual any number of times, assuming that such opportunities are available. The change of the attributes does not disturb the social set up of man but modifies the community organisation.

The two general populations interact with each other under the mechanism of a response system (Figure 5.1.) The stimulus of material wants, S, in Figure 5.1, provides the energy for running the system and lies in the psychological field of man. A man responds to it by acting upon those environmental variables which are external to the interacting man, *e.g.*, agricultural land or some dissimilar category of workers. The output of material gains, such as raw-materials or manufactured goods, feeds back want satisfaction to the worker and his dependants, or moves to the other variables of the environment. The response system has a complex internal structure where the output of one variable acts

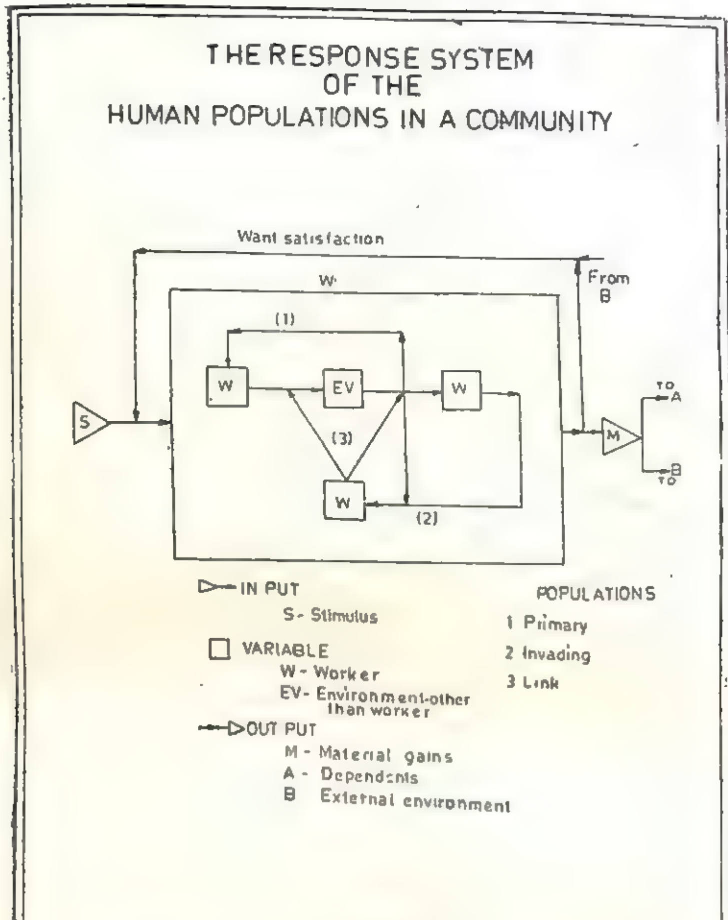


Fig:-5-1

as the input of another indicated by the direction of the arrows from one *W* to another in Figure 5.1.

The mechanism of the response system operates at three spatial scales. Family unit is the lowest scale where the output is shared by the non-earning dependants of the working members of a family. The mechanism does not operate where a family does not have any earning member. At the higher scale, the mechanism operates at the village level. Non-working population of a village is assumed to be dependant on the working population of the

village. The villages with different internal structure of the response-system interact with each other at the environmental level. Thus, a village is the fundamental level of study of a response system as used in the following sections.

The Dependency Ratio. The response system at village level is expressed as the dependency ratio. It is the ratio of non-workers to workers and can, more conveniently, be expressed as the fractional size of workers in an aggregate of individuals, such as in a village clump. The environmental average of workers based on the villages of the three tracts, is 0.3262 or 32.62 per cent. The standard deviation of the observed cases is 0.0323 or 3.23 per cent. No where does the size of workers drops to less than 20 per cent implying that *at least one-fifth of the total population of a clump must be engaged in the gainful employment for economic survival of the aggregate as a clump.* On the other hand, in some cases the workers' ratio can rise to 100 per cent lowering the dependency ratio to zero. There can be short term fluctuations in the dependency ratio lowering or raising it from the average level though converging towards the average in the long run.

The dependency ratio is low when the ratio of the workers rises above 32 per cent, *i.e*, mean+2 standard deviation. The high percentage of workers occurs only in 10 per cent villages and is associated with the undercrowded clumps (Chapter 4). These are the areas of low ecological density as prevail in the areas of the encroaching meanders in the VFS and in the underdeveloped clumps of the Khola zone under the BES. Thus, in the case of Bhagwanpur Khadar (G-104) in VFS of the Ganga, the ecological density is so low as to provide 54.37 acres of cultivated land per person with the workers' ratio of 75 per cent. Similarly in Khanpur Makhanpur (G-115), located in the Khola zone of the Ganga, the worker's ratio is 100 per cent with 50.25 acres per person.

The low dependency ratio is also associated with *the urban shadow* or urban influence, operating in the villages with urban contact. The ecological density is high with less than one acre of cultivated land per person yet the fractional size of workers is high. In the areas bordering some towns, such as around Delhi and Ghaziabad, daily migration of persons to the urban areas

raises the size of the population of workers. They grow independent of the land resources, finding gainful employment in industries or services of different types raising the ecological density. This is the case with Ghukna at the northern margin or Ghaziabad town where workers' ratio is 51.92 per cent, out of which about 69 per cent are engaged in big or small scale industries. The ratio of workers in Arthala (H-069), 3 kilometres from Ghaziabad is about 42 per cent out of which about 41 per cent are in some industries. These villages are part of the modified Khadar environment, the modification being caused by the urban phenomenon.

The dependency ratio is high where the workers' population is less than 25 per cent, *i.e.*, mean—2 standard deviation. It covers less than 8 per cent of the total villages of the three Khadar tracts. It prevails only in the villages with the urban contact such as at Sarai Khadar (G-011) with only 20 per cent workers though all of them are farmers. This is apparently due to their better ability of farm management acquired through the urban contact using a higher technological level. Fewer workers can support a larger population.

A prevailing dependency ratio apparently is associated with the internal structure of the response system classifying workers into some functional populations.

The Functional Populations. The workers contain the energy to bear the given dependency ratio. The size of workers represents the energy level in the organisation of two general populations. A set of the functional populations is divided into three divisions on the basis of the internal structure of the response system (Figure 5.1) *viz.*, the nature of inputs and needs. A prevailing dependency ratio at a given spatial scale is associated with the prevailing internal structure *viz.*, the nature of input and the type of feedback. Some workers are the direct absorber of the stimulus and are the direct carrier of energy. These are the *primary populations* using the local land resources for economic interactions. They obtain material gains as raw-materials to be used directly by them for their want satisfaction *viz.*, in the form of food ; or carry their gains to the other workers. Being capable of self-sustenance these populations have direct feedback in their

response system though they may opt for an indirect feedback by offering their output to the other workers.

The workers interacting with the output of the primary populations are *invading populations.* These workers produce the output of finished or semi-finished goods but are incapable of self-sustenance without their output being circulated by other workers through marketing or other services. The workers maintaining the circulation system are *link populations.* Link populations also are incapable of self-sustenance unless other populations provide them with matter or energy for the circulation system to be executed by them. The dominance of the indirect feedback is shared by the invading and the link populations as shown in Figure 5.1. Each set of the functional population has its own auxiliary attributes grouped into the species of workers. The actual size of workers represents the energy level that enables functioning of all the workers together as a unit organisation, *i e.*, the community organisation.

The primary populations are the set of workers interacting with the local land resources for direct want satisfaction (Figure 5.1). A man in this category moves himself to the given parameter, *viz.*, agricultural land. He is capable of providing the raw-material for the basic need of food, hence forms the basic populations.

The primary populations are first to appear in a community where a clump is just beginning to occupy a spatial segment of the habitat in the form of a new clump (Chapter 4). These primary populations are the *pioneer populations* (Appendix D, Table 5.1) identified as the only species of the functional population in a small size clump which was uninhabited earlier.[7] Pioneer population may choose to have only direct feedback in their response system by keeping the output at subsistence level. This can occur where clumbs are located in almost spatial isolation. As clump increases in size, increasing the field of its spatial interaction, primary populations choose to include indirect feedback in their response system to complement the material gains which they cannot obtain diectly from land resources. In the process the pioneer population grows to a *mature primary population.* These land

7. Not necessarily coinciding with the Census years.

based primary populations are composed of the constituent species of workers as cultivators and agricultural labourers. They also tend to be part time dairy workers.

(*a*) The *cultivators* are the largest of all the primary populations. The average fractional size is 0.6372 or about 63 per cent[8] of the total working population. The size ranges between 50 per cent and 80 per cent. However, the fractional size rises to 100 per cent or so in the case of new clumps (Appendix D, Table 5.1) where it represents the pioneer population, *e.g.*, at Bhagwanpur Khadar (G-104) and Kothla (G-126) (Appendix D, Table 5.1). Some non-pioneer clumps, *e.g.*, Pooth (G-147) also have more than 80 per cent of cultivators. This is due to the spatial isolation caused by the meander sweep or gully erosion.

At some places the size of cultivators drops to less than 50 per cent, such as at Jagola and Ghukna in Ghaziabad town. The reduction in size is an indication of the urban shadow, *i.e.*, the interaction of urban environment with the segment of the Khadar environment. The cultivators can operate with minimal level of energy expenditure circulating in a community organisation. It is the lowest where cultivators form the pioneer populations and their fractional size is large, *viz.*, more than 80 per cent. The expanded energy level in the form of increased work force displaces a part of the population of cultivators reducing their fractional size. Continued energy expansion and highly mobile and efficient circulation system can lower the fractional size to less than 50 per cent, bringing it to zero in the urban areas or keeping the percentage share to less than 50 per cent as an indication of the urban shadow.

(*b*) The cultivators are supported by *agricultural labourers* as another set of the primary population with the average fractional size of 0.0931 or about 10 per cent of the total workers. The actual size at village level varies in such a way that it is about two times the average in VFS of the Ganga and about half the average in other Khadar tracts and BES of the Ganga. There are two types of the agricultural labourers in relation to the energy expenditure.

8. Based on 1971 Census. The '81 census lumps many categories of workers together as one category.

One type of them are temporary labourers who are actually marginal farmers. They represent energy expenditure more than that can be used by the available size of land resources being worked by them. Such a situation results from the meander encroachment along the channel in VFS or BES. This category of labourers reverses as cultivators with the expansion of the size or the productivity of land resources. Thus, the size of agricultural labourers can be much above the average in one year of meander encroachment in the VFS of the Ganga but the same village can have small size in the next census year if meander recedes from the village and soils are mature enough to be used by the cultivators.

The other category of labourers is more permanent where the availability of energy required for utilization of the land resources is owned by few individuals and is not enough for resource utilisation. This lack of energy is complemented by hired labourers. This category of labourers is more common in the BES. These areas do not show significant changes in the fractional size of the agricultural labourers from year to year unless there is some social resetting while the fluctuating category of labourers is associated with the pioneer populations, for example, in Jalalpur (G-012) in Table 5.1. This category is associated with the clumps of stable populations in nearly all the villages under the BES.

(*c*) Some of the primary populations may also work as the unregistered dairy workers. While adult males perform the heavy work associated with the cattle, females collect fodder while the old and children tend cattle in fields. In most of the families dairy cattle supplements food resources of man and is the only source of food during inundation. It is associated with direct feedback. However, each family also has some surplus milk for sale. The amount of milk for sale depends on market price which in turn decreases with increasing time distance from market places which are located in urban areas. Milk is collected by vending *Dudhwalas* to be sold in city centres. Price offered by *Duduwalas* near Delhi along the Yamuna tract, as observed during the field work, was Rs. 2.80 per litre dropping to Rs. 2 per litre near Hastinapur along the Ganga but dropping still further to 60 paisa per litre at Sarangpur (G-109) in VFS which has small town of Shahjahanpur (Figure 1.1) about 14 kilometres away.

The workers in dairy farming etc. registered by the Census are full time dairy workers. They are dominated by an indirect feedback while only an insignificant part of their material wants is satisfied by the output of their response system. They work for the sale of dairy products. The fractional size of dairy workers is 0.0097 or about 1 per cent of total workers. They are virtually absent in the areas under VES of the Ganga becoming more common in BES, *viz.*, that of the Hindon and the Yamuna. Where they are present in the VFS their actual size may be as small as one or two persons though the actual size of dairy workers in the BES may be larger than ten persons. The fractional size of dairy workers in the VFS is about .004 while that in the BES is about .01.

The unregistered dairy workers are associated with seasonal disappearance of agricultural land common in the Khadar environment. Therefore, they are confined between man's place of work and of rest. The registered dairy workers represent high level of energy expenditure that extends from one environment to another, *i.e.*, across the rural Khadar and the urban Bangar. Linked with urban environment these workers represent the urban shadow operating in the Khadar environment. It is for this reason that their number increases close to the urban centres.

The three primary populations combined make the average of 0.73 of the total workers. However, the average in the VFS is 81 per cent against the average of 67 per cent for the BES.

The invading populations invade an area after it has been pioneered by the primary populations. They use the output of the primary populations as an input in their response system or use the land resources for non-food requirements of man (Figure 5.1). A very insignificant part, if at all, of the output of their response system can directly lead to their want satisfaction. The output must be circulated among themselves or to other populations before the invading populations can gain want satisfaction. Thus, the indirect feedback dominates in their response system without any option. As their survival depends on the circulation system they need a larger expenditure of energy than is required by the

primary populations. Consequently, the invading populations appear only where the clump size expands so that the available energy level is high. Therefore, they cannot live in spatial isolation as can be done by primary populations. They follow the spatial sequence along a circulation line, *e.g.*, a road, or create one almost instantaneously while invading an area. They are composed of the workers in industries and manufacturing.

(*a*) *Industrial workers* are the populations working in household and cottage industries. They have an average fractional size of 0.0737 or about 7 per cent of the total workers. The average is little indication of the spatial trend. Industrial workers are highly localised at a few industrial centres. The actual size is one or two persons in the VFS. The actual size in the BES can be more than 10 persons. Thus, the average fractional size in the VFS is about 0.001 while that in the BES it is 0.125 or about 13 per cent of the total workers.

Irrespective of the size, the industrial workers have energy expenditure higher than that can be absorbed by the local land resources. In other words, they are characteristic of a clump size that is overcrowded with respect to the carrying capacity of land. The size of industrial population can vary according to the degree of overcrowding (Chapter 4) and the circulation system as these populations are dependent on the circulation system for bringing the inputs and moving out the output. Location of these populations tends to be constrained by the proximity to some exchange centre minimising the cost of moving the inputs and the outputs. Since urban centres act as nodes of circulation lines, *e g.*, roads or communication lines, location of industrial centres and cluster of industrial workers is associated with the urban shadow. Thus, Mamipur (G-064), a village of ex-servicemen, has 17 per cent of industrial workers despite its location in the VFS. Most of the other industrial centres are located close to Ghaziabad and Delhi in the Hindan tract (Table 5.3, Appendix D).

(*b*) The manufacturing workers are those invading workers who work in large scale industries, *i.e.*, other than the cottage and household industries. The environmental average of these workers is 0.036 or about 4 per cent of the total workers. They are highly

localised in space, like the industrial workers, therefore, the average size of the manufacturing workers in the VFS is nearly zero or *trace i.e.*, less than 0.001 while in the BES, it is about 2 per cent along the Ganga, about 3 per cent along the Yamuna and more than 10 per cent along the Hindon, raising the average to 5 per cent in the BES.

The response system of the manufacturing workers is dominated by an indirect feedback like the industrial workers. The output of these population has to move through a larger number of the response-systems, therefore, it requires a larger and more efficient circulation system. For this reason their location is highly biased towards the circulation lines. A *friendship road*[9] may be constructed along with the establishment of a manufacturing unit, as was the case observed during field work at the valley flat area of Nagla Gosain (G-076) where a Khandsari unit was recently established. In most of the other cases the manufacturing units are located along some highway and the manufacturing populations string all along the line. It is for this reason that the Hindon Khadar tract shows a high fractional size of the manufacturing workers located along Delhi-Saharanpur and Delhi-Ghaziabad highways such as Jagola[10] with 78 per cent and Ghukna[11] with 46 per cent. These populations have a high percentage of industrial workers who supply accessories to manufacturing population of the same area.

The combined fractional size of the invading population is 0.1097 or about 11 per cent of the total workers. However, the average size in BES is about 0.161 or 16 per cent in the BES and about 4 per cent in the VFS.

The link populations circulate matter and energy as inputs and outputs of the response system of all the populations including themselves (Figure 5.1). They are responsible for maintaining the feedbacks in the response systems. Like other populations size of the link populations is the operational energy level in a community organisation. They have four constituent species, each representing a different form of energy with its own place in

9. Cox, K R. 1972. *Man Location and Behaviour : An Introduction to Human Geography* John Wiley and sons, New York.
10. Area included in Ghaziabad town in 1971 Census.
11. *Ibid.*

a community organisation. These species are workers in construction, in trade and commerce, in transport and communication and in 'other services'.

(*a*) The *construction workers* are those associated with raising of multi-dimensional features, such as dams and roads, and buildings etc. In all cases they are associated with expansion of human interactions in two or three dimensional physical space. Physical expansion is limited by water and rugged terrain in the areas under VFS and in the Khola zone respectively but has a wider scope in the other areas *viz.*, in the segments under the BES. The environmental average size of the construction workers is 0.007 with 0.05 in the VFS and 0.01 in the BES. Some of the villages in the BES may have exceptionally large size of the construction workers, such as in Mohiud-din Kinauni (H-071) that has about 7 per cent of the construction workers. The other cases of the large fractional size of construction worker are associated with the urban shadow or operation of the urban phenomenon in the rural Khadar.

(*b*) The *trade workers* are the workers in trade and commerce circulating energy through monetary and financial transactions. They circulate energy inputs and outputs of a response system by converting it to monetary form. The environmental average size of these populations is 0.0214 or about 2 per cent of the total workers though they are absent in most of the villages of the VFS while the fractional size can be two times the average in the BES and also be more wide spread than in the VFS. As their essential task is circulation they can be biased towards invading population in their spatial location. In many villages along the highways in Ghaziabad and Baghpat Tehsils the fractional size of the trade workers is more than 6 per cent. Thus, Asalatpur or Faruknagar, (H-065) has 16 per cent of these populations with 28 per cent of the total of invading populations.

(*c*) The *transport workers* are the workers in transport and communication They are responsible for physical movement of matter and energy in a community organisation. The matter and energy may be in the form of man, goods and information. The environmental fractional size of the transport workers is 0.0147 or

little more than one per cent of the total workers. They are trace in size in the VFS but can be many times more in some of the villages under the BES. The transport workers of the VFS are associated with the break of the bulk or the change of the mode of transport, such as from land to water but those of the BES are associated with the nodal junctions of the circulation lines. Thus, Passaunda (Y-039) has about 7 per cent of the transport workers located at the junction between Delhi-Ghaziabad-Saharanpur highway. The transport workers in the BES may be present in all the clumps but are concentrated where a large gully-*cum*-transport line descend to a valley flat. Thus, Alipur Morna (G-068) above Kishoripur (G-069) colluvial cone, has the fractional size of 0.0178 though Ikwara (G-059) and Akbarpur Gharhi (G-007) North and South of Morna do not have any population of transport workers. Kishoripur (G-079) and Mamipur (G-064) at the foot of the cone have transport population of the size of 0.029 and 0.0416 respectively, the inhabited village of Makhdumpur (G-062), North of Mamipur, has none and Jalalpur Zora (G-071) South of Kishoripur-Mamipur complex, has only 0.005 of the transport workers. In contrast, the fractional size of transport workers is greater than 0.1 in the villages of the superimposed series. There are places, *e.g.*, Kotana (Y-010) with the fractional size of 0.0462, located close to the junction of Bangar edge and the Yamuna channel. Mohiud-dinpur Kinauani (H-071) with almost the same type of location along the Hindon, has the fractional size of 0.06.

(*d*) The *other workers* are the workers in 'other services' which are the services of all the miscellaneous types. They offer their service for promoting, maintaining or modifying the circulation of man, goods, money or ideas between the different clumps. The environmental fraction size of these populations is about 0.1061 or about 11 per cent of the total workers. However, they are absent at most of the places in VFS while the size increases to more than 20 per cent in many villages of the BES of the Yamuna and the Hindon, representing the superimposed series of the environment. Thus, Shamshpur (H-062) 11 kilometres from Ghaziabad and Bhadoli (H-054), 8 kilometres from the same town has the fractional size of 0.218 and 0.219 respectively. Nagla Firoz Mohananunpur (H-043) and Muthrapur (H-057) just North and South of Shamshpur (H-062) have fractional size of 0.004 and

0.044 respectively. The 'other workers' concentrate at a few nodes at the Bangar edge offering 'other services' to the neighbouring villages dropping the size of these populations in the surrounding villages in the VFS where the species of these populations is often missing. Thus, 'other workers' maintain a flexibility in their spatial location with relation to other populations as well as to other species of link populations.

The combined average size of all the link populations is 0.1487 or 15 per cent of the total workers in the three environmental tracts. The average size is larger than that of invading populations largely because they are more widespread than are the invading populations. The actual size everywhere is larger in the areas under the BES than under the VFS, however, there are no clear cut areas of concentration such as in the case of the invading populations near Delhi and Ghaziabad.

Thus, the total working population of the Khadar environment is divided among the primary, invading and link populations in the ratio of about 74, 11 and 15 per cent respectively. The three ratios can be studied together if drawn to same scale in the form of the *ecological pyramids. The primary populations form the base of the pyramid* and the invading and link populations are superimposed above them according to their respective size. The ecological pyramids drawn for different villages have vastly different appearance (Figure 5.2). The pyramids of valley flat, specially along the Ganga are dominated by the primary populations. So much so that the flat with encroaching meander has only primary population, *e.g.*, in Tarbiatpur Junubi (G-095) while other pyramids representing the Bangar edge or valley flat villages of medium series show the ratio closer to the environmental averages, *e.g.*, in Gesupur Shumali (G-096). There is the third category of villages where the pyramids have smaller base with larger upper bars. These are the inverted pyramids which either have a very large size of the invading or link populations, such as in the case of Ghukna (in Ghaziabad) or have large size link populations as in the case of Jagola (in Ghaziabad). These villages are located close to the urban areas.

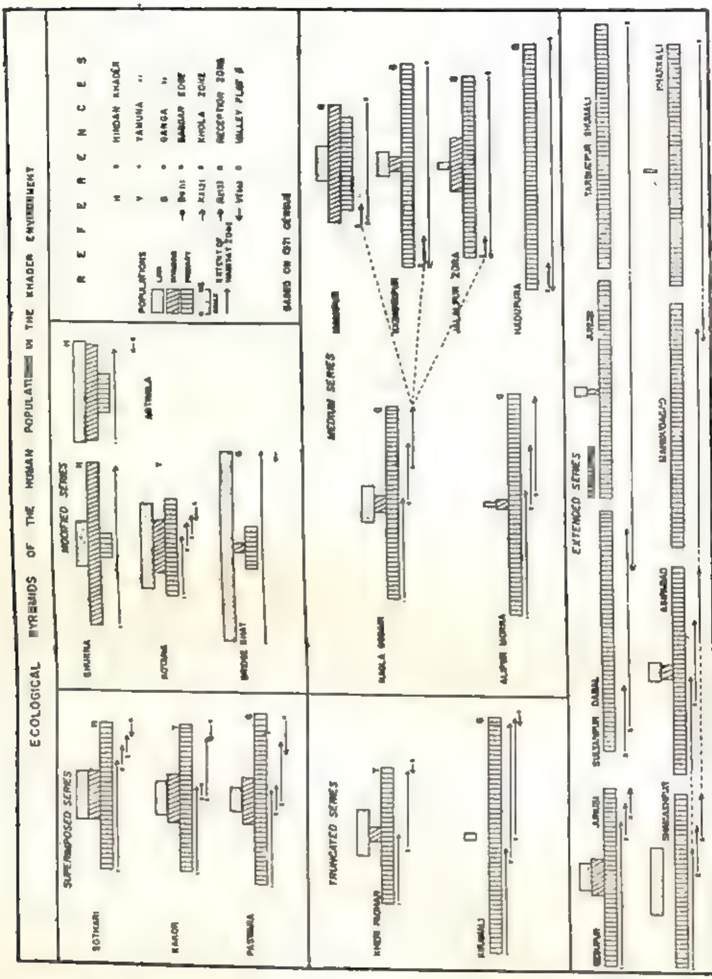


Fig. 5·2

3. THE FUNCTIONING OF COMMUNITY ORGANISATION

The three sets of the functional populations are related in such a way as to provide maximum material gains to the entire performing element. Since the size of the total functional population is a unit, dislocation in the set of one population sets the translocation of the other populations till the performing element can attain the maximum material gains. The maximization provides self-sufficiency at the spatial scale related to the performing element. The village level performing element not only has the

clearest expression but can also be used for deriving statistics for the environment level. The associated self-sufficiency can be local, based on a single village clump, or can be regional, based on a cluster of villages ; and environmental, based on all the villages in a single environmental tract. The three scales of self-sufficiency are extended along the yardstick of the normative distribution ratio.

The normative distribution ratio is the proportions of the three functional populations for maximization of material gains for the spatial self-sufficiency at a chosen scale. The ratio is based on some *simple assumptions* as :

(*a*) A clump size is adjusted to the carrying capacity of land and is big enough to accommodate the required size of the three sets of the functional populations. This is the characteristic of a mature clump with stable growth pattern (Chapter 4) and is common in the villages under the BES, specially of the superimposed series of the Yamuna and the Hindon.

(*b*) The clump has access to a moderate size of resource base which is used for a gainful employment. This is the common case in the villages of the BES mentioned above. The villages in the VFS, have constant building and destruction of the area under villages therefore, the resources size may not always be moderate enough for the distributive ratio.

(*c*) The clump is served by a moderately efficient circulation system that links individuals of the populations (*i*) to the resource base that provides inputs of a response system and (*ii*) to a market absorbing the output of the response system. The condition is satisfied with roads and cart tracts that are smaller in status than a national or State highways. This also is a more common condition of the BES (Chapter 6) than that of the VFS.

A theorem of the normative distribution ratio for spatial self-sufficiency can be derived on the basis of the three above mentioned assumptions. The theorem would be applicable under *two constraints, i e.,* the prevailing technological level and the dependency ratio. The prevailing dependency ratio is such that

one adult has at least an average of two dependants. The prevailing technological level is such that one working individual can barely use the land resources in such a way as to satisfy material wants of two persons. This would require more than half of the total functional populations to be working as primary population, leaving the rest to be shared by the invading and link populations.

The normative distribution ratio among primary, p, invading, i, and link, o, populations under the above mentioned constraints, would be

$$p=\frac{2}{3}\ F,$$

$$1-p=(i+o),\ i=\frac{F}{3}=o$$

where

$$F=p+(i+o),$$

i.e., F is the total number of individuals in the functional populations.

This is the *theorem of local self-sufficiency* at village level where i and o are shared equally in a village. Assuming that a village has a total of three workers sharing the functions of primary, invading and link populations and providing material want satisfaction for himself and his two dependents, the ratio would be

$$\frac{2.0:0.5:0.5}{3.0}=1 \text{ or } 66:17:17=100 \text{ per cent} \qquad (1)$$

A village with such a ratio would have little spatial interactions with the other spatial segments and would live in virtual spatial isolation. Such a case is provided by Subhanpur (H-040) along the Hindon which happens to be a Harijan village. However, a spatial segment is more likely to interact with other segments, therefore, the theorem would not be spatially prevalent.

A man's interactions in space spreads over the larger area as the circulation system becomes more efficient and link populations grow in size, though concentrated more at some place than at the

other. Increase in their size is complemented by decrease in the size of the invading populations. Based on the local resources the size of the primary populations remains largely unaltered unless there is some change in the local resources as well. Mutual adjustment provides the regional self-sufficiency where a decrease in the size of a population other than the primary populations in one village is compensated by its increase in some other village. These villages are located in a single or two different contiguous habitat zones There is some degree of local self-sufficiency as long as the displacement does not reduce the size of one population to less than half of the other, while their combined share still retains one-third of the total population of workers. Thus, the equation (1) is modified as

$$66.0 : 11.5 \leqslant 22.5 : 11.5 \leqslant 11.5 = 100 \text{ per cent}$$
$$i.e. \quad i \leqslant l/2 \text{ and } i+e=F/3 \qquad (2)$$

Equation (2) is the *theorem of self-sufficiency at regional level* while primary populations retain their numerical dominance, invading and link populations attain a flexible range of 11 to 22 per cent. It shows a greater balance between a clump size and the carrying capacity of land. It also indicates an improved circulation system without leading to the excessive circulation. The equation (2) can be traced at Mirpur Hindu (Y-038) along the Yamuna which is 27 kilometres from Ghaziabad and about the same distance from Delhi.

Generally the circulation system extends much beyond the two neighbouring villages of the habitat zones. It may cover all the spatial segments of the environment. A man may remain localised at one spatial segment but he gets access to a larger resource field. The adjustment between the clump size and the carrying capacity is diffused over a larger area. The size of the invading and link populations in one-village may drop to one-third of the other, compensated by the increase at some other place. At the same time, the size of the primary populations may fall in one village compensated by its increase in the other. The combined share of the invading and link populations remains one-third of the total workers (equation 1) but as a separate category they can fall to the minimum of 25 per cent and rise to the maximum of 45 per cent where the minimum and the maximum can occur in different

villages. A village may also have the minimum of the both compensated by the expanded size of the primary populations that increases to 83 per cent. Else a village may have the maximum size of the invading and link populations reducing the primary populations to a bare minimum of 50 per cent. Thus, primary, invading and link populations would have a range *i e.*,

$$50 \leqslant 83 : 8 \leqslant 25 : 8 \leqslant 25 = 100 \text{ per cent}$$
$$i.e. \quad i \leqslant l/3 \text{ and } i+l=F/3 \qquad (3)$$

for the *environmental self-sufficiency*. The average size of the three populations, according to the equation (3) would revert to equation (2), but for the upper and lower threshold values.

Each population, according to the equation (3) would have a minimum and maximum *threshold size* for self-sufficiency at a chosen scale. These thresholds are less than 50 per cent and greater than 83 per cent for the primary populations and less than 8 per cent and greater than 25 per cent for the invading and the link populations. A community where the primary populations fall below the threshold would change from a rural to an urban community. Such a transitional community is an *inverted community*. On the other hand, the size of the primary populations may increase beyond the upper threshold, truncating the size of the invading and link populations below the level of the minimum requirement for self-sufficiency. These are the *truncated communities* where some constituent species of workers are absent or are trace in size. The communities corresponding to either of the three equations are in equilibrium with either other environmental variables or with each other and are called the *normal communities*. The examples of the three types of the communities are shown as the ecological pyramids in Figure 2.5.

The observed averages of the three combined Khadar tracts for the three population has the ratio of 74, 11 and 15 per cent for the primary, invading and the link populations respectively. The primary populations are over represented and the link and the invading populations are under represented in the VFS while the BES is more balanced. The villages observed to have normal communities form 64 per cent of the total villages while only 8 per cent have inverted communities (Table 5.3, Appendix D) and 28

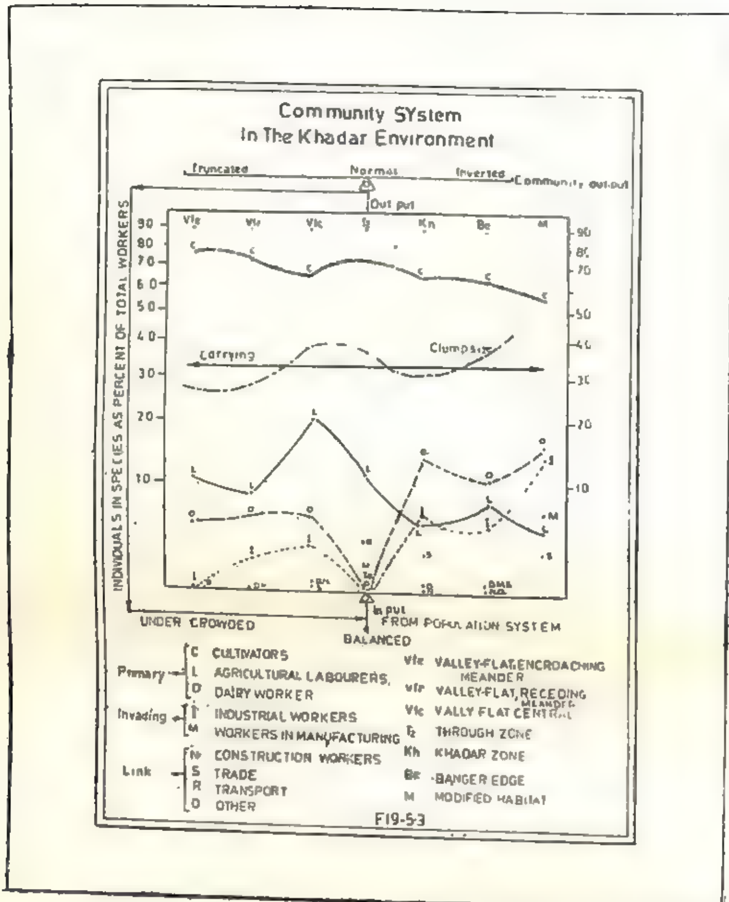
per cent have truncated communities (Table 5.2, Appendix E). A village community can always change its form through the dynamics of the community organisation.

4. THE DYNAMICS OF COMMUNITY ORGANISATION

A village community may conform to the normative distribution ratio or deviate from it depending on the validity of the three assumptions raised earlier. As the Khadar habitat is highly dynamic (Chapter 2) a clump size and the resource base are changing leading to the readjustment of the community organisation. The changing structure of the functional populations and the related clumps size are shown in Figure 5.3. The prevalent community organisation in a clump is a stage in the populations succession moving from a partially formed truncated communities to the diversified-populations normal communities with decreasing proportion of the primary populations. Continued succession may lead to an inverted community organisation where the fractional size of the primary populations is the lowest possible under the rural communities.

A populations succession is initiated with the pioneer stage. The primary populations account for 100 per cent of the total working populations in the areal unit. As a result the other two functional populations are missing from the community organisation. Such communities are associated with two constraints. First, the clump size is undercrowded, so is too small to provide even the minimum required energy to be used by either the invading or the link populations. Secondly, the resource base measured as the cultivated area is larger than can be worked upon by the clump size as the consequence of the first-condition indicating under crowding (Chapter 4). The areal segments with such constraints are the new clumps (Chapter 4) of the receding meanders.

The *pioneer communities* can be of two types. There can be those with the mono-populations of cultivators alone or those that have more than 83 per cent of cultivators supported by agricultural labours, jointly accounting for 100 per cent of the total workers in the spatial segment. While the former type may be



truly indicative of a pioneer community the latter may result from disintegration or decay of a higher order community organisation, such as is common in the areas of a meander encroachment. The former type of a pioneer community may be located anywhere in any spatial segment of the environment, though being more frequent in the VFS along channel with a receding meander and in the Khola zone of the BES. The latter category is more restricted to the areas along the channel being worked upon by meander encroachment, either in the VFS or in the BES. Thus, Bhadwi (G-044) in the VFS along the Ganga and Kutubpur (G-114) in the BES under the Khola zone of the Ganga are the examples of the former type of the pioneer communities while

Mirpur Sadho Nagla (G-085) is the example of the latter (Table 5.1, Appendix D).

The changing composition of the functional populations with the changing clump size is shown in Figure 5.3. It is based on the average values of the three tracts. It shows that the *normal communities* (central part of the graph, *Be—Vfc*, Figure 5.3) of the Khadar tracts are diversified. Dependency ratio ranges between 50 and 70 per cent with the average clump size. The share of the primary population is reduced but the proportionate share of all the non-cultivators populations is increased. Some populations, *viz.*, workers in constructions and in transport and communication are absent in the communities of the valley flat system where the primary populations tends to move towards the higher side of the threshold. The observed normal communities are more prevalent over the areas under the BES than under the VFS, being most common along the Yamuna, less along the Ganga and the least along the Hindon.

The observed *inverted communities* of the three Khadar tracts (Figure 5.3) are more diversified than the normal communities where the clump size is larger than the carrying capacity. The diversification occurs at the cost of the share of the primary populations reduced below the threshold size. All the constituent species are present and the share of all the species tends to be 1 per cent or more. Most of these communities are present near Ghaziabad along the Hindon and a few are present close to Delhi border, *e g.*, at Loni (Y-040) along the Yamuna and Hastinapur Kaurawn (G-031) near Hastinapur town along the Ganga.

A type of community can be assigned to a village at one period of time through certain stages in the population successions.

A *pioneer stage* can grow into an *incipient stage* dominated by the primary populations and accompanied by the trace size of one of the other two functional populations. The slump size remains smaller than the carrying capacity of the resource base which may expand slightly more than in the case of the pioneer communities. The actual number of the accompanied non-primary population may be as small as one or two persons being less

than the minimum size of 8 per cent required for any self-sufficiency. Functioning of a normal community organisation remains disrupted due to the absence or small size of at least one of the functional populations. Some of the incipient stage communities may actually be the reminiscent communities denoting a break down of the previously existing higher order community organisation resulting either from the shrinking resource base or emigration or both. Though incipient and reminiscent stage communities have similar composition of the populations the two can be differentiated from each other by tracing their previously existing populations compositions. Thus, Parsapur or Hansapur (G-021) and Khanpur Garhi (G-087) in Table 5.2, Appendix D are the reminiscent stage communities while Kheri Kalan (G-053) has an incipient stage community (see Figure 5.2 for the ecological pyramid of the stages).

An incipient stage can progress further into a *rudimentary stage*. The primary populations continue to dominate with a further increase in the size of the resource base but are accompanied by both the other two types of the functional populations. The size of the two non-primary populations may be smaller than the minimum threshold hence even these communities lack the functioning of a normal community organisation. The clump size may be small though may be either over- or under-crowded. While the latter condition is associated with progression of the community organisation the former is associated with decay of a higher order community organisation. Decay is the case at Mirpur Sadho Nagla (G-085) while the stage at Shirjeypur (G-032) further North results from the progression.

The rudimentary stage can continue to progress forming a *mature stage* of a normal community if the resource base and the clump size continue to expand balancing each other. They are numerically dominated by the primary populations but the other two functional populations are also present within the normal range of the normative ratio. The resulting normal community is also a diversified community with local and/or regional self-sufficiency. Though the size of the primary populations is lowered, it is compensated by sufficiently increased size of the invading and link populations for the spatial self-sufficiency. In this light they

are the climax communities under the rural cultural environment with the population composition corresponding to the normative distribution ratio of the three equations (1), (2) and (3).

A *climax stage* of the normal community can remain stable as long as the clump size and the resource base maintain a balance. The balance is destroyed either because the clump size grows larger than the resource base forcing man to depend on the resources located outside the territory of his village or by adding in some way to the local resources. The former case results in daily commuting by workers, normally as member of the invading or link populations. Though the land resources are more or less fixed in size, other resources are added as the inputs of the invading and link populations. The local resources base remains unchanged and an increase in the clump size beyond the carrying capacity of land upsets a normal community organisation reducing the fractional size of primary population at the cost of invading link populations. The three functional populations reach a new balance where the size of the primary populations is reduced to less than the lower threshold of 50 per cent. A normal community organisation, dominated by the primary populations, is inverted with the dominance of the invading or link populations or the both resulting in the inverted stage.

The *inverted stage* is marked by the size of primary populations being smaller than the minimal threshold requirement. These can be classified as industrial or service centres. The size of the invading populations is larger than the maximum threshold creating an industrial centre with inverted community ; the size of link populations in larger than the maximium threshold resulting in an inverted community with a service centre. A community in a given spatial segment may be inverted combining both the industrial and service centres. While Sisana (Y-022) (Table 5.3, Appendix D is an example of an inverted community with industrial centre, Kuri (Y-002) has the inverted community with service centre and Arthala (H-069) has both. As is clear from the Table most of the villages with inverted communities are located at or around Ghaziabad urban centre.

As mentioned above, the inverted stage of the succession results from the increased quantity of the inputs from the environment other than that associated with the local land resources. The source area of these inputs is the external environment located outside the Khadar environment. The external environment providing the inputs for the overgrown link population is the service centre essentially located in an urban environment. The inputs of the industrial centres may initially be located in a rural environment but as the industry continues to progress it involves expansion of the link populations providing the required services for its expansion encompassing the source area from the rural to urban environment. Thus, an external environment is virtually an urban environment opposed to the Khadar environment. The inverted communities are the indicators of the urban shadow from the external environment operating in the Khadar environment. It may be recalled that the urban centres located within the spatial framework of the Khadar habitat have been excluded from the scope of this reserch work (Chapter 1). However, these towns (Figure 1.1.) are the source areas throwing urban shadow where the intensity decreases with time-distance along the link lines (Chapter 6).

The three Khadar tracts of the Ganga, the Yamuna and the Hindon provide examples of the different communities corresponding to the different stages in the populations succession. About 12 per cent of the total villages have pioneer communities (Table 5.1). Most of them are located in the VFS of the Ganga, some in the Khola zone of the Ganga but none of them are located in the Khadar tracts of the Yamuna and the Hindon which have less dynamic habitat. Only 5 per cent of the villages have incipient communities (Table 5.2), confined to the Ganga Khadar tract while about 10 per cent of them have rudimentary communities spread over the Ganga tract. Inverted communities (Table 5.3) account only for about 8 per cent of the total villages where about 6 per cent are located in the Hindon tract while 2 per cent is shared by the Ganga and the Yamuna. This leaves about *64 per cent of the villages with the normal communities spread over the three Khadar tracts.* The pioneer, incipient and rudimentary communities have sub-self-sufficient size of the primary

populations and can be grouped together as the *truncated communities* accounting for 27 per cent of the total villages against 64 per cent of the normal communities with little over 8 per cent of the villages with inverted communities.

Apparently, the statistical distribution of communities is slightly skewed in favour of the primary populations which is in keeping with local resource base of a rural environment. It also establishes the fact that the normal communities, dominated by the primay populations, are not only normal but also are representative of the Khadar environment. The Ganga Khadar tract is the most representative of the environment where all the stages of succession are present. The Yamuna Khadar tract is controlled where many stages are absent. The Hindon tract is not only controlled but also modified where the inverted stage is widespread. As such the three Khadar tracts themselves can be graded with the Ganga Khadar as the most representative of the Khadar environment, the Yamuna with less of it and the Hindon with the least developed Khadar environment. In this context, it may be recalled that maximum field work was done in the Ganga Khadar tract, less in the Yamuna tract and the least in the Hindon tract (Chapter 1). All the three tracts have well developed agricultural populations but the industrial development is well below the normal except at Ghaziabad urban centre.

Irrespective of the type, the Khadar communities are likely to undergo periodic and aperiodic changes. A normal community may change to an inverted stage or slump to a pioneer one. On the other hand, the pioneer stage may shoot into an inverted stage without the intervening stages. The periodic changes have known periodicity of recurrence, therefore, can be predicted at any point of time. Aperiodic changes are associated with irreversible processes, usually non-Khadar in nature extending into the Khadar environment. They cannot be predicted on the basis of the known parameters of the Khadar environment alone.

The periodic changes in a community organisation occur in the area with periodically recurring Khadar proceses, *viz*, a meander sweep. A meander encroaches and recedes with the known periodicity resulting in the shrinking or expansion of the

resource base which in turn is adjusted by the dynamic community organisation. In some years of the exceptional rainfall, a meander may encroach abruptly, disrupting the sequence of succession. A dry year may enhance the period of succession or lengthen the life of a normal community. Barring these exceptions, the sequence of change in a community organisation can be estimated once the rate of the meander sweep is known.

The aperiodic changes in a community organisation are associated with some organic parameters of the Bangar or a neighbouring environment interacting with the Khadar environment. Directly or indirectly, the organic parameter in question is a man. A man causes aperiodic changes either by accelerating mass wasting or by extending a link system. The mass wasting is acclerated due to deforestation or poor soil management at the Bangar edge. Its immediate effect is the extension of or adding to the Khola zone but it has far reaching effects on the resource base. Directly or indirectly it reduces or impoverishes the resource base. Therefore, man and his resources attain a new balance in the form of truncated or reminiscent communities. The mass wasting may be controlled through afforestation or improved soil managements. This may stop further deterioration of the community organisation.

Aperiodic changes associated with the expanded link system, are associated with the neighbouring external environment of a different type of a community organisation. The non-Khadar community may be complementary or supplementary of a Khadar community. That either necessitates expansion of the link line or accelerates the efficiency of the already existing link system. The expanded link system provides a wider accessibility to the man in the wider resource base of the different nature. The changed resource base is adjusted by attaining a different equilibrium community organisation. The community organisation in the neighbouring Bangar may not be very different from that of the Khadar community though an urban community is essentially a complementary or supplementary community, providing services or the finished goods not available in the rural environment. Thus, the expanded link system becomes operative only in association

with the urban shadow. The urban shadow operates from a non-Khadar external environment, located essentially in the urban centres.

The interaction of the Khadar and the neighbouring non-Khadar environment produces the ecotone relationships. In functional terms the neighbouring environment is urban, therefore, *the ecotone relationships are incorporated by the inverted communities.* In addition, growing of 'Palej' crops during the dry summer months in the channel bed of the Ganga is an ecotone relationship. The usufactury rights of the channel bed are leased out by government to contractors from urban centres. They raise these crops with the help of labour hired from the external environment. Truck loads of the product moves back to urban centres as long as the water level does not rise in the channel bed following the melting of snow in the upper reaches of the river.

Some ecotone relationships may appear as *random noise* (Walmsley)[12] in a Khadar community organisation. These relationships are located within the spatial framework of the Khadar environment but cannot be explained fully on the basis of either the Khadar or the urban attributes alone. These relationships appear occasionally at some spatial segments and cannot always be predicted. Fishing and hunting are two such ecotone relationships that appear aperiodically as random noise in some Khadar communities. They are performed by man of an urban community interacting with the Khadar resource base.

Fishing is an economic activity performed during the period of maximum inundation. A man of the Khadar community is preoccupied by the safety of his life and property against the inundating water Such preoccupation often forces him to move to drier and safer areas in the Bangar or Bangar edge. This leaves the fish resource to be worked upon by others. This provides an opportunity for an urban man to descend to the water pools of the Khadar for fishing. The catch is taken back to the urban centres which provide easy markets for fish products. Hunting

12. Walmsley, D.J., 1972, *Systems Theory : A Framework for Geographical Enquiry*. Research School of Pacific Studies, Department of Human Geography Publication Ha/7/1972, Australian National Univ., Canberra.

may be done for recreation, for gainful employment or for both. The natural vegetation along swamps and along river banks and islands is used as hunting ground of birds and wild deer by the hunters from far and near towns. This hunting operation may be assisted by some folks from the local villages providing gainful employment to these people for a day or so. Fishing is widespread in all the Ganga Khadar, as at Asilpur (G-108) 11 kilometres from Shahjahanpur (Figure 1.1).

Sometimes a random noise may have more lasting and widespread effects. Such interactions involve construction of dams and bridges and controlling and diverting a channel. These interactions are initiated by the decisions of man in some urban centre, *viz.*, an administrative centre with no direct link with a Khadar tract. It modifies the Khadar environment in such a way that a channel may flow without being accompanied by the associated Khadar habitat. Such is the case of the Hindon South of Ghaziabad town from where water is diverted to the Yamuna. It results in the modified habitat series (Chapter 2). Other examples are located along the railway line at Bridge Ghat (Figure 2.6) and along Meerut-Moradabad highway (Mawana) along the Ganga (Chapter 2).

The ecotone relationships including the random noise, enable the Khadar and its neighbouring environment to interact with each other binding a Khadar community organisation to a larger system, *i.e.*, *rural-urban eco-system*. The Khadar community system acts as an open system interacting with its neighbouring urban eco-system.

5. THE CONCLUSION

A community is structured with the populations that are aggregates of individuals similar in some ways and differentiated from the individuals in other aggregates. The component populations can be apparent or general. The apparent populations are based on the differentiating attributes of caste, religion and literacy. These populations lack interdependence and are the static structures of a community. The general populations are logical divisions of a genus aggregate of individuals. A division is based on the gainful employment of individuals as workers and non-

workers. The two are interrelated, the relationship is measured as a dependency ratio. The dependency ratio of the three Khadar tracts is such that one-third of the total population of a clump supports two-thirds of the rest representing the average ratio of workers and non-workers.

The relationship between the two general populations is organised by the internal structure of workers in the form of a community system. The system is structured with the different categories of workers which collectively form a set of the functional populations. A functional population is lower order stimulus-response system where a worker acts under the stimulus of economic wants. The material gains in the form of the output of the response system feed-back want satisfaction to the responding man and his dependents. Some functional populations can have the option of direct feedback. These are primary populations of the cultivators and agricultural labourers. Unlike these are the invading populations whose output must be circulated by some other populations in order to provide the want satisfaction. Thus, an indirect feedback is inevitable in case of the invading populations. The functional populations circulating the matter and energy for all the populations including themselves, are link populations invariably with a more complex feedback relationship (Figure 5.1).

A community system can occur in three possible states. There can be a normal community where man is in equilibrium with the carrying capacity of the local resources, the different sets of functional populations. This state is marked by the spatial self-sufficiency in terms of the basic human needs. These communities have a threshold size of each of the functional population. *The size of primary population varies between 50 per cent and 83 per cent of the total workers. The size of invading and link populations varies between 8 per cent and 25 per cent as the lower and the upper threshold.* A community system occurs in a truncated state where the size of the invading or link populations falls below the minimum threshold. The system occurs in an inverted state where the size of invading and link populations becomes larger than the upper threshold size needed for the self-sufficiency.

A community system can operate at three spatial scales on the

basis of self-sufficiency. At the lowest is the family scale. Some families may be without an earning member at least for some time. A community system is not easily identified at this scale on all the occasions. On the higher scale, a community system operates at village level where a clump of a village is composed of non-workers and the three sets of the functional populations. One village clump can be in one of the three states and interacts with another village clump in a different state. The actual interactions of clumps with different states, located in different spatial segments, operate the system at the highest scale, *i.e.*, environmental scale. The truncated communities under the VFS along a channel interact with the inverted commun ities under the BES, located at Bangar edge with urban links.

These spatial interactions define the complex boundaries of the community system. On the one hand, it shares its boundaries with the inorganic habitat system as part of the Khadar environment. On the other hand, it shares its boundaries with the rural and urban systems as part of a much larger cultural environment. In fact *the Khadar environment is a sub-set of rural environment covering the Bangar and the other habitats. The urban system is an external environment*. Inverted community organisation is the ecotone between a Khadar-rural and the urban environments. Normal organisation is the result of ecotone between rural Khadar and Bangar. Truncated organisation is the ecotone of rural Khadar and the habitat system. Thus, community system is as complex as the organism in question, *i.e.*, man, focused in human ecology.

6

The Settlements and the Lines of Circulation in the Khadar Eco-system

I. THE INTRODUCTION

The organisms are the carriers of energy running the eco-system. They locate themselves in space to interact with the environment in the eco-system. The plants are virtually immobile by location. Location of animals is too transitory to be defined with precision with reference to a small spatial segment, *e.g.*, a Khadar tract. Man's location is neither so fixed nor so mobile like plants and animals. He raises fairly permanent structure, like nests of birds to shelter himself and his belongings. These structures are dwellings of the visible expression of man's presence in the environment. Man makes irregular tranjectories, like birds in space, only to return to his shelter sooner or later unless he moves out from the environment through out-migration. The tranjectories are often repeated over the same linear space forming pathways or the lines of circulation. The dwellings and the inter-linking pathways form a settlement and have such a relationship where change in one leads to the change in another. These inter-related changes set the dynamics of the settlements. The set of relationships together with the elements of relationships function as the settlement system. This chapter studies the Khadar settle-ment system as a variable of the Khadar environment. It focuses on the dwellings as the hardware storing the energy of the eco-system ; on the circulation system of energy ; and on the dynamics of the settlements as the inter-play of the dwellings, circulation system and the other variables of the environment.

2. THE DWELLINGS

The dwellings are the *hardware* for sheltering the energy of the eco-system when not in use. The energy units may be in terms of households, their belongings or their services. The hardwares containing the energy units are houses. Collection of houses is located over the built-up area of a village and is called a hamlet in the census records. *The hamlets occupy only 2 per cent of the total village area in 90 per cent of the cases.* It is a part of a village, *i e.*, the revenue mauza that is the smallest areal unit for collecting revenue as well as the census information. The local name for a hamlet is '*abadi*'.

The energy units and the unit hardwares may be equal in size when the number of houses and households are the same. This is possible when the energy content is low, *i.e.*, when households and their belongings are few and the services rendered by the associated community are none ; or when the expansion of the hardware is constrained for some reason. About 80 per cent of the villages under the VFS fall in this category. The disparity in the number of houses and the households amounts to less than 10 units in the remaining cases. The disparity is greater in the inverted communities, specially close to the urban centres. Thus, Garh rural (G-133) has 264 households accommodated in 132 residential houses. The neighbouring Bridgeghat (G-136) has only 12 houses for 1,358 households.[1] The villages which had some gap between the number of houses and the households during 1961 Census closed on the gap during 1971 Census except in the case of large villages. Thus, Palwara (G-141) had 484 houses for 428 households in 1961 compared with 463 houses for 496 households in 1971. The neighbouring Alamnagar (G-145) had 491 households in 418 houses in 1961 and changed to an equality with 501 houses and households.

The shortage of the houses occurs where the number of households grows larger than that can be contained within the assigned space for the 'Lal Dora' covering about 2 per cent of the total village area. Further expansion in the number of houses

1. Based on 1971 Census.

would involve encroachment on agricultural land which may not be possible under the given community structure.

The size of the hardware as the number of houses and households bears relationship with the attributes of the VFS and the BES. The two numbers stay below 100 in the VFS along the channel, are between 100 and 150 over the middle terrace under the VFS and over the Khola zones but increase beyond 200 in the Bangar edge and some valley flat villages along the highways. Assuming that the middle terrace and the Khola zones have self-sufficient store of energy, the Bangar edge villages with urban shadow have extra stored energy which can be used, if needed, for the areas under the VFS along a channel where the storing capacity is small. For example, Saifpur/Firozmohanpur (G-010) at the Bangar edge with the urban shadow, has 441 houses and 441 households, storing enough energy to spare for the operation of the eco-system at Daulatpur/Malipur (G-032) located in the trough zone of the immediate vicinity and having only 14 houses and 14 households.

The stored energy is related to the installed capacity to store. The latter is measured in terms of the number of rooms per dwelling unit. There are only one room dwellings[2] in the villages under the VFS though multi-room structure is more common in the BES. Four walled structures of a valley flat are multipurpose though additional partial enclosures may be used by a household more often for some functions than for others. The common use is sheltering cattle. In some cases a separate dwelling, *bail khana*, may be raised as a cattleshed. The recent migrants tend to have a separate structure for storing grains. These are *kothas* raised above the ground level at some distance from the dwelling unit. These *kothas* were observed at Rampur or Niamatipur (G-130) and Dudhali Khadar (G-055) in the houses of the Punjabi refugees Single-room dwellings are uncommon in the BES and are associated with the recent migrants of the temporary workers. In all the cases of the VFS and BES there is a separate hardware facility for storing cowdung and hay. The presence of these structures is an indication of the near universal presence of the

2. Based on field observations.

domestic animals interwoven closely in the economic system of the area.

Thus, *the installed storage capacity is related to the actual magnitude of the energy liable to be expanded in a given spatial segment*. The maximum energy is stored under the BES with the *urban shadow*, and the least at the valley flat along channel under the VFS, and at the trough zone. There is inter-action between the two spatial units with dissimilar storage capacity in the form of the other variables of the eco-system studied in the previous chapters.

The installed capacity has scope for expansion as the associated eco-system is dynamic. A dwelling unit can be expanded vertically to increase its installed capacity as and when the need arises. The expansion appears as the added number of storeys. A single storey is the rule in the area under the VFS, double storey may be present in the areas under the BES but is a common feature of the BES with the urban shadow. This is the supporting evidence of the attribute that the BES with the urban shadow has the maximum energy in use and in store for circulating through the eco-system.

A modal of the hardware is suited to the needs of the environment using it. As such, the dwelling of the Khadar are specially designed to suit the variable attribute of inundation in the environment by way of a plinth.

The dwellings are raised over plinths in the area where the level of inundating water in the years of normal rainfall remains less than 2 metres for less than a week. The height of these plinths is about 2 metres on an average. A plinth is not raised where inundation is deeper and longer. In most of the cases of the plinths of the VFS, the height is less at the outer periphery of an *Abadi*[3] and increases towards the centre. The tendency to gain height is associated with the age of a dwelling site. The dwellings are renewed at the same site year after year and the debris from the old dwellings keeps accumulating and adding to the height of plinths. The houses at the periphery of

3. Area under residential dwellings.

the Abadi or Lal Dora are comparatively new, hence their plinths do not achieve the added height. They are raised abruptly along the streets but slowly towards the centre of the Abadi. The general appearance of a cluster of houses raised on the plinths is that of streets like the ravines and the dwellings like the badland hillocks.

Some dwellings are actually located on the non-functional plinths as those located at the ravine-heads in the Khola zone. The headward-erosion of ravines penetrates into the built up area with streets which are actually ravines and a cluster of dwellings located over the Khola hillocks. Even in these cases the debris of the old houses may raise the platform of a dwelling. Some other hamlets have non-functional plinths such as those located over the ruins of a fortress. The collected debris acts as an added plinth for the entire cluster of the dwellings in the village. They appear to stand on a hillock even though located in deep Bangar. Shahpur Chaudhari (G-127) in the Khola zone of the Ganga provides an example of the dwellings in the badlands of the Khola zone and Loni (Y-046) along the Yamuna is an example of the dwellings located over the ruins of a fort. The main hamlet of Loni stands on approximately 20 metres high hillock formed by the ruins.

Some houses in the Bangar edge sub-system may be raised on plinths for the reasons unrelated to the variable of the Khadar eco-system, *viz.*, to keep off ground moisture or any other unwarranted thing. Yet the absence of a plinth in the BES is as much a feature of the dwellings as the presence of it in the valley flat sub-system.

The hardwares may be constucted with different raw materials so that the dwellings of the Khadar eco-system have a variable building material. It is generally affected by the availability of the raw materials in the habitat but has more specific impact of the variable of inundation. The building material used for construction of dwellings may also be an indication of the period since the dwelling has come under use.

The clay (or mud) is the most prevalent raw material for making dwelling. It is commonly available raw material as the

habitat is set in the structureless clays of the Gangetic trough. It is mixed with cowdung and stored and seasoned for four-five days before use. There are important exceptions in the valley flat sub-system, *viz.*, in the trough zone where soils may be too wet; and along bar and point bar deposits where soil may be too loose to be used for construction. Invariably, there is never much distance between the areas of availability and the place of use.

The intrinsic feature of inundation and meander sweep in the valley flat sub-system is the additional contributory factor in clay houses. Inundation and meander encroachments reduce the life span of dwellings. A farmer surviving on low productivity of soil can barely afford to invest much in the building material of a dwelling needing frequent reconstruction, hence uses cheaply available mud for raising his dwelling. The dynamics of the habitat weakens over the Bangar hence the dwellings can be more permanent, substituting clay by brick or other building materials.

The clay walls tend to have a thatched roof or may have brick lining over a wooden frame and plastered with seasoned mud. The walls may be too weak to carry the weight of any other heavy type of roof The floors also have mud plastering. About 80 to 90 per cent of the dwellings in the eco-system are made of the seasoned clay.

The straw as the building material may be another exception to the otherwise common pattern of the mud houses. It is used as the building material of very temporary dwellings. The screens of straw may have in some cases a covering of polythene sheet to drain off rain water. Local dry grass, stalks of wheat or rice, or sugarcane leaves are used as raw material. Bamboo or wood may be used as the supporting frame.

The temporary shelter, as provided by such straw huts, is needed by the temporary workers in a community structure (Chapter 5) or the transit camps of the permanent workers. The former category includes the agricultural labourers hired by the outside contractors (Chapter 5) to work in the Palej fields for six months or so. The contractor winds off his work as soon as the Palej fields are inundated by the rising water level so that the hired labour easily moves out from the environment. Some of these

workers raise a thatch hut, '*Jhonparhi*' in the fields itself while others live in a neighbouring village making a very temporary dwelling.

A thatch hut as a transit camp may be used by the farmers or the permanent workers of the eco-system returning to the habitat after the period of meander encroachment. The field may not be productive enough for supporting the family till that time. A few performing elements return to the habitat and shelter themselves in these temporary dwellings till they can raise a more permanent dwelling for the family requirement.

Such straw huts as temporary dwellings would be more common in an ever changing dynamic rather than in a static habitat. The VFS of the Khadar habitat is more dynamic than the BES, hence, the temporary thatch dwelling is a common feature of the former rather than of the latter. The straw huts of the latter may be temporary as in the VFS but are definitely associated with the lack of resources of man or as a measure of economy rather than resulting from his interaction with some variables of the eco-system.

The brick as construction material of walls is uncommon in the VFS but is prevalent in the BES. Floor and ceiling pattern is flexible. Floors may have brick with mud or cement and roof may have brick-mud over wooden frame or have lenters. The bricks are manufactured in the kilns located in the BES or outside the Khadar environment over a dry ground. They have to be transported a variable distance to the areas of the VES if they are required there. Transportation is very difficult due to absence of the metalled roads in the VFS (refer to the section on the pathways) so are costly. Moreover, a brick house plastered with mud is liable to be washed off by a strong current of water so heavy investment is avoided.

There are exceptions in the VFS using bricks. These are cemented brick walls which can withstand the onslought of water current from the channel. The initial investment in these dwellings is much more than can be met by the agricultural returns of the infertile soils (even of the fertile productive soils) of the VFS.

These exceptions of brick and cement dwellings, therefore, are associated with the well off immigrants recently settled in the area. These are not the products of local agricultural production (Chapter 5), *e.g.*, the dwelling of the Sikhs in Rampur or Niamatipur (G-130).

The examples of the dwellings of bricks with mud plaster can be traced in the villages undisturbed by a meander sweep for some years though located in the VFS. There is the observed case of Manoharpur (G-042) in the extended series of the Ganga. It had not been affected by a meander sweep for about ten years till 1975. Located over an abandoned levee top (Figure 2.4) a large part of the village remains free of inundation giving reasonably sufficient agricultural returns to farmers. Some of the farmers had raised brick-with-mud dwellings in the village. However, a small bayou had opened along the northern side of the village *Abadi* in that year threatening the dwellings including those of brick-mud material.

Unaffected by the dynamics of the habitat system the BES can afford to have more permanent dwellings so that brick-mud dwellings are common in the sub-system. Wherever the owners have enough resources, brick-mud dwellings are substituted by brick-cement dwellings.

The attributes of dwellings as hardware storing energy in the form of man, his services and his belongings can be summarised to study its place in the functioning of the eco-system. The actual amount stored, installed capacity and its expansion is greater in the areas of the BES with urban shadow in contrast with the scant amount under the VFS along a channel. The disparity appears in the form of the models of hardwares with or without plinths and the durability of the hardwares in the form of its building material. The disparity necessitates the interaction which is a part of the functioning of the eco-system. The functioning has its fullest scope in the extended series which has all the possible habitat zones, therefore, has all the possible variations in the attributes of the dwellings. It is limited in the moderate series with limited habitat zones while the truncated series have incomplete functioning where some habitat zones are missing. The dwellings are

adjusted to a modified habitat under the modified series. A super-imposed series is the parent series out of which other series are carved, therefore, may contain all the variables of the dwellings mentioned above. Thus, the dwellings are closely related to the output of the habitat system.

The dwellings are no less related to the other variables of the eco-system. *Storage, its capacity and its expansion is low where size of the modified plant communities is small* (*Chapter 3*) *and increases with an increase in the size of the cultivated plants.* As such the attributes of the dwellings have a contributory effect of the output of the biotic system. In keeping with it the dwelling size is small where a clump size is small, *viz.*, under the VFS (Chapter 4) and increases with the increasing clump size of the BES with urban shadow. Remarkable is the association with the community system (Chapter 5) where small dwellings are associated with the truncated communities of the valley flat along a channel under the VFS and the large dwellings are associated with the inverted communities of the BES with urban shadow. Thus, the dwellings are the combined output of the previously mentioned systems as the components of the eco-system.

3. THE LINES OF CIRCULATION

An interaction among the dwellings of the variable attributes pre-necessitates a circulation system linking them. Man makes repeated tranjectories over a line to execute the interactions. There are the lines of circulation or the pathways. Some of them are internal, linking one dwelling to another or a set of dwellings (ward or a mohalla) to another. Others are external pathways, linking a cluster of dwellings to another, *e.g.*, paths between two villages or between a village and a town. Internal pathways are part of a village *Abadi*. They are mostly used for circulating man in and out from his dwelling thereby affecting individuals and are of little significance in the eco-system. The external pathways link the different spatial segments of the environment. These are the lines of circulation contributing to the circulation of matter and energy affecting or resulting from the dynamics of an eco-system. They are generally referred as a footpath, cart tract, *kuchha* (unmetalled) or *pucca* (metalled) road as the ascending hierarchy of the pathways based on the quantum of circulation running

through the lines. Ferries and bridges are the links in otherwise interrupted circulation lines.

A Liki occupies the lowest rank in the hierarchy of the pathways. It is a muddy line of a footpath serving the pedestrians or cyclists. They *appear where the frequency of circulation is low and the volume of matter or energy to be circulated is small.* They are the result of and lead to a few interactions of the matter and energy among the interlinking dwellings. They run through privately owned fields, areas of dense mat of grasses or other natural vegetation ; or through narrow dry gaps in a wet area running over the uneven terrain. Constrained by their surroundings, often they are just wide enough to keep a foot on the surface.

The function of *likis* is to conserve energy of man in motion. This is done by providing a short cut to a longer path or by lengthening a path to avoid some obstacle by going around it. The obstacle may be a patch of swamp, marsh, hillock or a water body. Some of the obstacles cannot be avoided altogether such as a shallow stream. The likis cross a stream at the riffles where the channel is shallow though the currect is fast (Chapter 2). These likis curve downstream in the channel bed keeping with the rate of the turbulent velocity. This can be felt as feet drag downstream where the velocity is increasing and a liki is curving out. As the maximum velocity in the channel is passed, the liki curves back towards the original straight line path. Thus, path is lengthened across the channel but some human energy is saved.

Most of the *likis* connect man to his farm but some likis connect one hamlet to another. Often, the only spatial link between the BES and the VFS villages may be through the likis, *e.g.*, between Asilpur (G-108) in the Khola zone of the Ganga and Sarangpur (G-109) in the immediate valley flat in contact.

The *likis* may develop at some places to the higher hierarchy of pathways or may disappear due to some changes in the environmental variables. A change to the higher forms is often restricted by the spatial constraints. The disappearance is possible by overlaying a *liki* with some other use of land by man or by opening a

better organised alternate link. A short cut link may continue to exist.

A Dagarha has a higher rank in the hierarchy of the circulation lines with the *greater frequency and the quantum of matter and the energy in circulation* among the settlements. It is an unlined road or a tract used by carts, cyclists, pedestrians and trucks laid over the community land. Its surface is marked by the lines of ridges and furrows made by constant running over of the wheels, and by small pits made by hoofs of animals. They are barely wide enough for accommodating two carts or trucks at a time. *Dagarhas* cut across the muddy and dust laden areas and appear as ravines entrenched to some depth in the surrounding areas.

The function of a *dagarha* is to circulate man, as in the case of likis, but more important is *circulation of material goods in such quantities as cannot be transported by pedestrians and cyclists between the connected points in space.* In addition, they may provide short cut to a road between the two points. A *dagarha* may not always have two way circulation. More often the circulation is from one or all points along it, such as in a valley flat, to a common point at the other end, such as an urban place or a large service or trade centre in the BES (*e.g.*, Asifabad, G-091, node in Figure 6.1).

The *dagarhas* run over gentle slopes. They link the output of the unlike communities. There is very little scope of the movement of matter and linking *dagarhas* from one point in the valley flat sub-system to another with the similar community structure (Chapter 5). Avoiding steep slopes, *dagarhas* tend to run parallel to the channel in a valley flat or perpendicular over a colluvial cone. They cross over to the areas under the Bangar edge subsystem by running through wide ravines (the illustration in Figure 6.1 shows four cart tracts crossing over the colluvial fan West of Mahmudabad and Sultanpur Dabal to join the node at Asifabad (G-091) gully in the BES.

The *dagarhas* cross through the water bodies where the depth of water is less than 2 metres (instead of detouring round them like likis). The material goods loaded in carts tend to get wet while passing through these water bodies. The goods liable to be

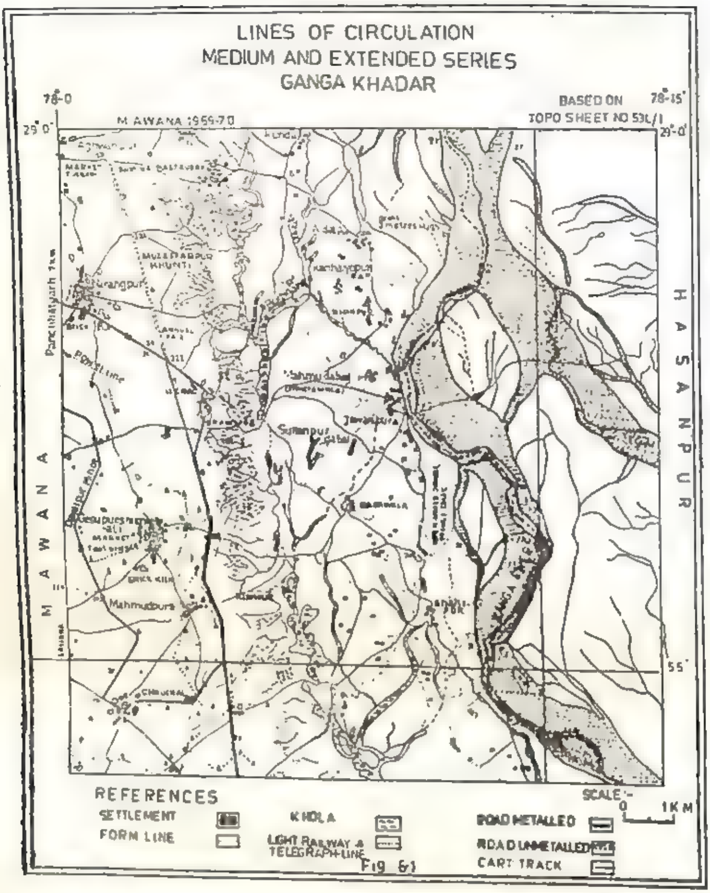


Fig 6.1

damaged by water are loaded over the other things such as the stalks of grains or sugarcane leaves. Where a *dagarha*, used by trucks, runs through a water body, the passage is filled with litter of dried stalks or leaves to avoid sinking of the tyres of the heavy vehicles as in the *dagarha* to Kharkali from the SW (Figure 6.1). A *dagarha* used by carts can pass through the swamps. The vegetation of the area is cleared altogether or tall plants are replaced by submerged category of plants (Chapter 3).

A *dagarha* may vanish from the landscape if the land under it is taken over by an encroaching meander. If not, a *dagarha* may persist in the Khadar environment in the face of the competition with roads. At places a *dagarha* may only be a supplement to a

road, *e.g.*, between the settlements of Bhikund or Rustampur (G-045) and the brick lined road to Latifpur (G-046) (Figure 6.2). In the long run, however, the road is disused and the dagarha runs parallel or along with the disused road, as in the case of Bhikund-Latifpur dagarha. This is because the dagarhas are better adjusted to the attribute of inundation than are the roads.

The roads may not show an adjustment with the attributes of the environment. They are classified as *kuchha* or unmetalled and *pucca* or metalled roads. An unmetalled road may be brick lined. Roads are meant to be used for HTV and other fast moving vehicles, though everyone is free to use them.

The *function of the roads is to facilitate bulk movement of people and their goods.* The area of circulation can be much larger than is possible in the case of the lower hierarchies of the pathways. This is so because roads can be used by the fast-moving vehicles. The convergence of many likis and dagarhas increases the size of bulk movement resulting in or from the roads. The bulk movement is associated with the mass production of the *Palej* in a dry channel bed and sugarcane in the rest of the areas of the VFS. The produce from the *Palej*, *viz.*, cucumber, melons and gourds, are carried by contractors' trucks making use of the dagarhas but sugarcane is moved over the roads maintained by the Sugarcane Growers Association. The field work revealed that the Association laid many brick lined roads in the valley flat sub-system in the Ganga tract of Mawana around Latifpur (G-046) (Figure 6.2) in the late sixties and early seventies, though large part of them were damaged at the time of observation. These tracts are unrelated to the attribute of inundation and are often swept off by the over running sheet of water during high floods (Chapter 2). However, they have resulted in an easy circulation of sugarcane to the sugar mill at Mawana. The contact in turn has extended the urban shadow to the area resulting in the modified series. Figure 6 2 may be compared with Figure 2.4 covering the same area but without the roads. The latter shows the extended series, the former covers a part of it as the modified series in the later years.

Most of the brick lined roads are the shortest distance between some two points, therefore, run as a straight line (Figure

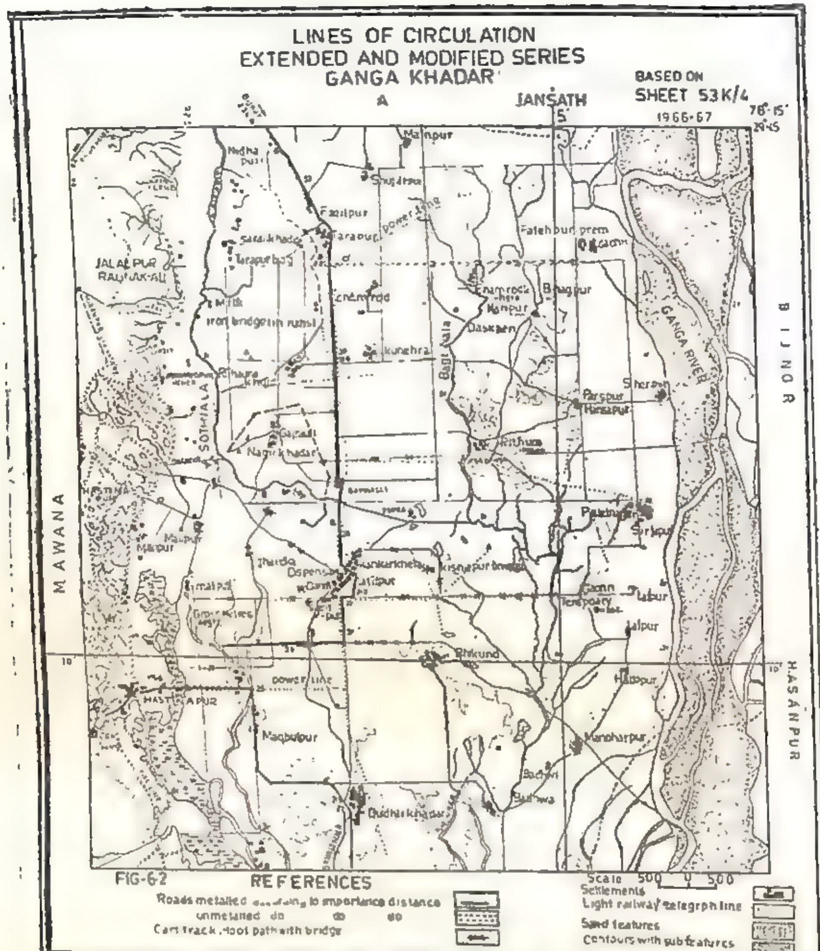


Fig. 6.2

6.2). They are not aligned to the attribute of inundation and tend to block the free flow of water at the time of inundation. The force of the accumulated water erodes into the road washing them off or damaging them in the process and making their surface highly uneven. It is for this reason that the *dagarhas* are preferred to brick lined roads in the Khadar environment.

A brick lined road can run almost from no where or can run parallel to each other with a short space between them or run perpendicular to each other crossing the area under the VFS (Figute 6.2). Most of them join some metalled road often in the

BES to join a highway (Figure 6.2) or an industrial centre *e.g.*, a sugar or khandsari mill. Some of the unmetalled roads run to a town instead which act as a distribution centre for the farm products, *viz.*, products from the *Palej.*

Some of the pathways include pucca road which have metalled surface. They are laid by public works department of the State or the Central Government. The overall location of roads may be based on some economic and social factors but the actual lay out is related to some attributes of the habitat. They follow the gentle slopes like the *dagarhas* (Figure 6.2). They cross the inundation prone areas over raised embankments. There are frequent outlets of hume pipes for draining out stagnating water. It keeps the flow of water so a road is serviceable at the time of normal inundation. When inundation is more than normal, a sheet of water runs over the embankment sometimes damaging the overlying road. The damage can occur during normal rainfall as well where the embankments are earth filled and are laid over the area of abundant sub-terranean flow of water. As the water table rises during rains, the sub-terranean flow becomes stronger which can lead to eroding of mud or earth surface damaging the overlying roads.

A road may not be functional for a large part of the areas under VFS where they are located over undamaged embankments. They may be used by individual pedestrian or cyclists but bulk movement by man all along the road may be difficult. This is so because the embankment has to be climbed over from the surrounding area which is generally at a lower elevation. Steep side slopes of the embankments are not easy to climb by local carts or vehicles carrying bulk unless some point of entry is available. These points are located where the road level is lowered or surrounding area is raised. These are the junctions of the *dagarhas* with roads.

The utility of a road in the Khadar eco-system is conditioned by the presence or frequency of the transport system plying through the area. *A road is non-functional in the eco-system if no transport service operates over it.* It has limited service if the frequency of the transport service is limited, *e.g.*, Mawana-Kishoripur road. It is efficient and a forceful line of circulation

if the transport service plying over the road is fast, *e.g.*, along Mawana-Latifpur-Bijnore road (Figure 6 2).

The examples of pucca roads running through the VFS are very limited. There is no such system in the Yamuna Khadar tract. There is only one road that crosses the entire length of Khadar tract located in the northern Ganga Khadar, *i.e.*, Mawana-Bijnore road (Figure 6.2). There are other roads that run from Mawana entering the Ganga Khadar at Mukhdumpur (G-062), Kishoripur (G-69) ; and at Abdullapur (G-128) terminating in the valley flat of the Ganga.

The ferries and boats provide *link in the circulation lines interrupted by some obstacles*, *viz.*, wet or inundated area. Boats keep to riffles of a channel (Chapter 2) to avoid the risk of running aground in shallow water and making use of the natural transport of energy. Ferries ply in deeper water. The points connected by ferries or boats result in inter-actions of man located on the two sides of the channel. Boats ply in the areas of less frequent interactions than in the case of ferries. Boats, therefore, can be seasonal or have less frequent service while ferries have more regular service. Small boats are used for relief and rescue of man marooned in the inundated areas of the valley flat sub-system. On the other hand, ferry service may be abandoned when water level increases in channel. The areas having boat and ferry service change with each dislocation in meander loops. There are few ferries across the Ganga as the channel has shallow areas of bar deposits or islands in the various meander loops. One such ferry point is shown East of Khanpur Garhi (G-087) across the Ganga in Figure 6.1. There are many such points along the Yamuna and the Hindon.

The ferry or boat crossings are replaced by bridges where the interactions across the channels are more frequent and involve many more individuals. There are some masonary or steel bridges, some are culverts over hume pipes and some are improvised bridges made up of tree trunks. Generally, wide and deep channel bodies are crossed by steel bridges. The channels of moderate width and depth have bridges of masonary structure. The hume pipes are generally used to drain off water stagnating

along the embankments with a passage over them. Narrow water bodies with localised interactions across them are covered by tree trunks. The underlying area tends to have a narrow, swift and deep rivulet, *e.g.*, a sota/nala/nadi. Straight tree trunks, such as that of a palm tree, are used for the purpose. The trunks may also be used as short cut bridge. In addition to these types of bridges, a pile of litter and mud, fills a shallow water body in the *dagarhas* used by trucks. Places with occasional interactions across a water body but with no bridge across, are crossed by man using a float, *e.g.*, a dried gourd or a pumpkin skin.

The permanent bridges are generally formed where a highway linking two urban centres runs across the Khadar environment. When special boats ply over the inundated area for relief and rescue operations the permanent bridges obstruct free flow of water developing pools or whirlpools around the support structures. In addition, some of these bridges may be too low or narrow to allow passage to boats. Such bridges are not welcomed by man in the VFS though may not affect man in the BES. The temporary bridges are better adjusted, folding during inundation allowing passage to the relief boats. Embankments attached to the large steel or masonary bridges may serve as a temporary shelter place at the time of flash inundation, but the utility is very temprorary. Moreover, many of the bridges with permanent structures tend to be damaged during the high flow in a channel. They remain unrepaired for a long time.

The valley flat sub-system of the Ganga provides the examples of all the types of bridges. There is a broken hume pipe bridge between Sarangpur (G-109) and Mishripur (G-113) (Figure 2.5) and many more east of Latifpur (Figure 6.2). The bridges of tree trunks are common across the Baghi and Soti nalas (Figure 6.1) in the valley flat of the extended series of the northern Ganga Khadar. Masonary bridges are located along the embankment for Mawana-Bijnore highway (Figure 6.2) and the Mawana road to Kishoripur. Steel bridge across the Ganga is located at Bridge Ghat (G-136) in the study area (Figure 2.6). There are many steel and other permanent bridges across the Yamuna and the Hindon. They serve man in the Bangar or in the BES. This is an indication of the dominance of the BES over the missing or limited areas of the VFS in these two tracts.

4. THE DYNAMICS OF THE SETTLEMENT SYSTEM

A hamlet and the linking circulation lines are often called a settlement. The settlements in the Khadar eco-system evolve through a diffusion process extending from the neighbouring environment. The process operates through the lines of circulation. The technique of studying the process is similar to plant succession (Chapter 3). The process causes a constant change in the attributes of the dwellings and the linking pathways. The set of the changes and the associated causes are the dynamics of the settlement system in the Khadar eco-system.

The dynamics of the settlement system operating in the Khadar eco-system is actually a continuation of the process that begins in the Bangar environment. Origin of the process of change is lost in time antiquity. However, the process of the change keeps re-occurring in the interlinked areas of the VFS and the BES. Man of the Khadar eco-system locates himself in the spatial segment of the Bangar edge from where he can interact with the Bangar as well as the Khadar environments or has more interaction with the Bangar than with the Khadar environment. As soon as the spatial segment under the VFS expands, at least some individuals begin to have more interactions with it than with the segment under the BES. These individuals move to the area under the VFS raising dwellings for themselves. Such a situation is likely to occur under the medium and extended series but not under the truncated series with limited area under the VFS.

The spatial segment in the BES leading to the habitation in the VFS is a diffusion centre, *e.g*, Asifabad, Gesupur, Salaur and Asilpur in Figure 6.3. Man makes various tranjectories in all directions from the centre to make economically more gainful interactions than he has in hand. Repeated tranjectories to the area under the VFS begins with likis and develops into a dagarha. Initially ravines are used as the passage from the Bangar edge to a valley flat while steep toe slopes may cause obstruction in the movement of man between the areas under the two sub-systems. Hence the diffusion centres tend to concentrate at or close to the broad ravine openings running likis and dagarhas. Location of a dwelling in the area of the VFS

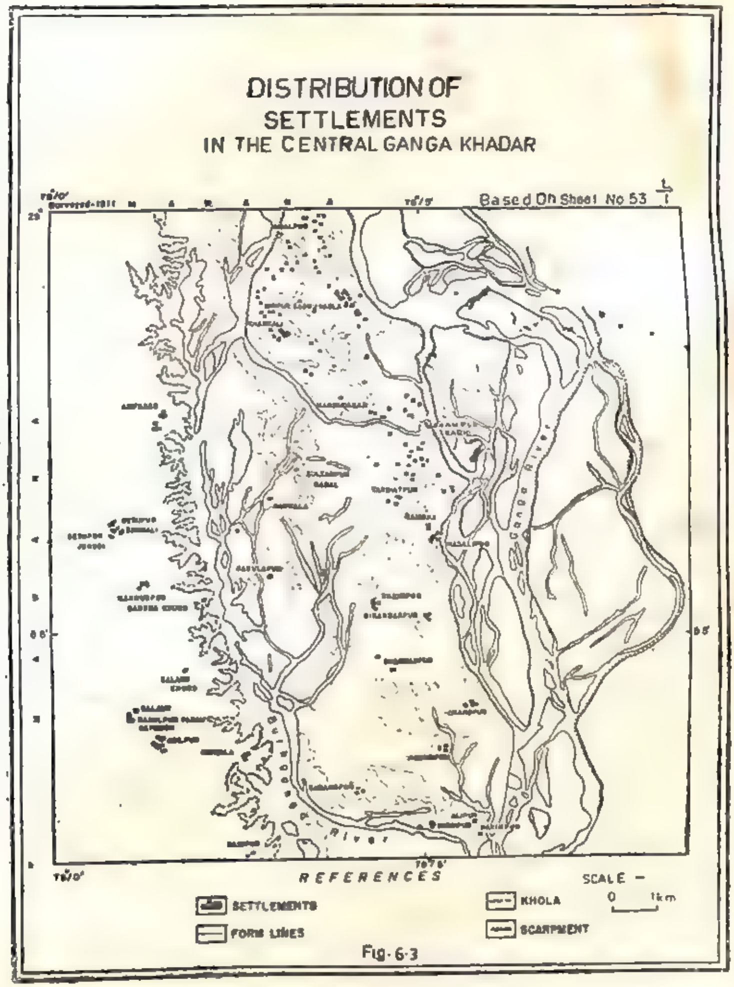


Fig. 6.3

attracts more dwellings. Initially each new dwelling is located in the area under the personal possession of the dweller. Each dwelling may stand separated from the other as a farm house or an isolated dwelling (as South of Bagwala, G-095, in Figure 6.1). It occupies the driest location in the privately owned land. Such dwellings dot over the abandoned bars and levees running along a line (Figure 6.3). This is the embrayonic stage in the evolution of settlements in the VFS associated with the truncated community organisation (Chapter 5).

The evolution process may proceed further if the variable of the habitat system does not assume a value unfit for the maintenance or expansion of the recently formed community as in the truncated series. The variable of the habitat system assumes a higher value when soils become fertile increasing the size of the modified plant communities and human community progresses towards a balanced organisation. It attracts more individuals and number of the dwellings starts increasing. Some of the dwellings attract each other and cluster at one locational niche as hamlet. The initial attraction for niche is provided by the preference for some caste or religion, sense of physical security or some chance factor. As community organisation becomes stronger, individuals become independent of each other and the choice of the locational niche moves from the factor of the private ownership to that of the safety from inundation. Hamlets also string along the highest parts of the abandoned bars or levee tops (Figures 6.1 and 6.2). A small hamlet is locally called a *madhayya*. It houses the population of one caste or social community alone ; individuals are related to each other. Where the hamlet is big enough to accommodate more members of the same social community or caste, the settlement is called a *majara*. Some settlements are named *madhayya* even after they cease to be hamlets.

A hamlet may revert to farm house or be abandoned if encroached by a meander sweep. If a meander stays out from the area, soils become maturer so that at least half of the village area is covered by the modified plant communities (Chapter 3). Community organisation tends to be balanced or moves towards the inverted communities (Chapter 3). Hamlets begin to grow into a larger cluster of dwellings as a village. The line bounding such a cluster of dwellings is the *Lal Dora*, as mentioned earlier. A village in the Khadar eco-system is confined within the *Lal Dora*. The dwellings cluster at the highest levee tops, surrounded by the cultivated plants on the levee slopes. As levees stand in close proximity to the channel banks, a village becomes a dry point settlement close to a wet line, *e.g.*, a channel, active or abandoned.

Sometimes a revenue *mauza* has two hamlets which are almost equally big. (The both are called village in the local language). One hamlet is the main village or has high caste population over the safer locations and the other is a satellite hamlet of

the economically weaker or Harijan population. They operate as a satellite hamlet of the main village. The villagers often use the term *Majara* for such a settlement. Rambha Nadalipur is a *majara* of Bagwala (G-095) in Figure 6.3. A satellite may evolve at the same time as the main village with the Schedule Caste population e g., at Rambha. A satellite *majara* of a village in the BES is often located in the VFS. The dwellings between Nagla Gosain at the Bangar edge and Jalalpur Zora in the valley flat in Figure 4.2 form a *majara* of the former village. In some cases a satellite is settled by the immigrants into a settlement detached from the main village though sharing the land in the revenue mauza. In a few cases, a satellite may arise through exodus of some members of a social community from the main village.

A village may grow further where some streets are shared by different clusters of dwellings and the built up area increases much beyond the average of two per cent of the total village area. Community structure grows on support of the resources other than the local land resources. Such an expansion is accompanied by some additional services and community structure moves towards the inverted organisation. Eventually administrative form moves from the rural to an urban and a village grows as an urban centre. Hastinapur and Rasulpur Dhulari (Figure 1.1) are the new towns located in the Khadar habitat. It may include a notified urban area, town, city or any higher form of settlement. A community develops inverted organisation (Chapter 5) with the enlarged link or invading populations, needing more efficient circulation system. The accompanying services, as defined by the Census of India cannot possibly be provided in the ever changing Khadar environment where the Khadar processes may completely eliminate the area of settlement from the environment Thus, the urban settlements cannot be a part of Khadar environment. The Khadar processes, hence the Khadar environment, is kept away from the urban area through man's conscious efforts (refer to Chapter 1). Some settlements may have overgrown size and additional service facilities with the inverted community organisation. These settlements result from the urban shadow of the external environment operating in the Khadar environment.

The diffusion process may have maximum possible coverage, whereby village settlements appear to be dispersed at random. The

nearest neighbour index, *R*, moves towards 0.25. In reality, there are bands of settled areas alternating with the uninhabited bands or negative niches. The settled areas are located at the Bangar edge, and the central valley flat intervened by the negative niches of the toe-slopes and trough zone. The channel and the lower terrace form another negative band on the channel side. The band contains the uninhabited village. The irregularity in zonation is caused by frequent settlements over wide Khola hillocks and dry gaps in the trough zone. This is the case of Asifabad (G-091) at Khola hillock (Figure 6.3) and Saidullapur (G-100) on an old bar. Occasionally, a levee of the lower terrace also may raise a temporary settlement. Since these zones are not always parallel to each other, settlement dispersal appears random.

An extended series has all the possible habitat zones, therefore, has more than one band of settlement in the valley flat. Medium series has only one band ; the truncated has none, the superimposed series may have the main village at the Bangar edge with hamlet in the valley flat (Figure 7.1). The modified series may have settlements in the valley flat made dry.

There are not enough records of the evolution process of the settlements in the Khadar tracts. Settlements of the different forms co-exist in time though occupying different spatial segments of a Khadar tract. A village settlement is the most common form. Each settlement form can be associated with certain value of the variable of the habitat system. Only the Khadar tract of the Ganga is wide enough to provide examples of the required values of the habitat system and the linked forms of the settlements. One settlement form can be linked to another through the operation of the habitat system, according to the evidences observed during the field work. The settlement forms linked in the logical sequence, though spatially unconnected appear as the sere (Chapter 3) in the settlement succession.

The settlement of Rampur or Niamatipur (G-130) in the medium series of the Ganga Khadar provides examples of the lower form of a settlement. The field work revealed that the village was nearly abandoned by the *Mallahas* who had sold

their land to the Punjabi migrants arriving at different points of time. Each fresh arrival of the migrants raised a farm dwelling in his farm land. Some of these dwellings are brick-cement structure, therefore, they retain their farm-house form without changing to other forms. Many of the other farm houses of the village were made up of mud houses. Members of some related families had clustered their dwellings together forming a hamlet of their own. Some of the original *Mallah* families of the village had their own hamlet. There were twelve such hamlets at the time of observation, each occupying different site in the same village area. These hamlets occupied the locational niches which were relatively free from inundation. The farm houses and the hamlets had grown in the short span of five years. Similar niches of Aidalpur (G-800) are shown in Figure 6.3.

Jalalapur Zora (G-071) and the surrounding villages in the valley flat sub-system of the Ganga Khadar provide an example of the higher settlement form (Figure 4.2). The neighbouring Hadupura (G-077) and this village were affected by the encroaching meander in the early seventies. The settlements were abandoned for short time in 1971. The meander receded in the following years resulting in the resettlement of the villages. Parts of Jalalapur Zora were cleared first followed by a part of the cultivated area of Hadupura. Individuals returned in ones and fews raising their dwellings in clusters forming four hamlets in Jalalapur. Some of these dwellings belonged to the farmers who have land in Hadupura but the hamlets were located in Jalalpur cleared earlier. A farmer chose that hamlet for his shelter which was closer to his fields and relatively inundation free. Meanwhile, the hamlets in Hadupura were cleared of the meander and the remaining individuals raised their dwellings as a village located at the new locational niche. The old locational niche stands abandoned at some distance. Mahmudabad in Figure 6.3 has five widely separated hamlets between Kharkali and Khanpur Garhi.

Tarbiatpur Janubi (G-095) provided the examples of the formation of a satellite settlement as observed during the field work. The village has two hamlets (Figure 6.1). The main

hamlet is called Bagwala and the satellite is called Rambha Nadalipur. The satellite belonged to the Schedule Caste population. The hamlet of Rambha Nadalipur and the neighbouring village of Tarbiatpur Shumali were affected by the meander encrochment in the early seventies. The entire Schedule Caste population of Rambha Nadalipur had shifted en mass to a new locational niche. Some of the *Malis* of the neighbouring Tarbiatpur Shumali (G-088) had shifted to Bagwala, joining population of their caste in that village but forming a small *madhajya* of two dwellings, standing slightly away from the main village. Alipur in Figure 6.3 is a *majara* of Sarangpur located far in the West though now the two form a single village of Alipur/Sarangpur.

The documental evidence of the settlement changes is provided by Aidalpur (G-080). The old toposheet, based on the surveys of 1911-14 (Figure 6.3) shows dispersed farm house settlement though the village had developed a nucleated village by the fifties (Figure 6.1).

The settlements are not always evolving. Each evolutionary stage is temporary in the valley flat sub-system. The form may change with each recession after a meander sweep. A settlement may disappear altogether during the period of meander encroachment, *e.g.*, Bhuwa (G-002) (Figure 2 4) in 1971 Census (Figure 6.2) or may shift to a new locational niche, as in the case of Nadalipur mentioned above. In some cases the main village may shift to its satellite hamlet. Such a case was provided by Hadipur Gaonri (G-040) (Figure 2.4) which was being affected by the meander encroachment in 1975. Many of the affected dwellings had shifted to Gaonri, a satellite of the main village. The remaining families were in the process of shifting. The spatial segments in the VFS relatively unaffected by the meander sweep can be fairly stable in the settlement form. Such is also the case of the settlements in the BES.

The negative locational niches of the BES and the positive niches of the VFS result from the interactions between man and the channel flow along a Khadar tract. Factors other than channel flow become responsible for the choice of locational niches by man in the neighbouring Bangar environment where the Khadar

eco-system ceases to operate. Moreover, as the Khadar habitat is dynamic, the character of the locational niches in the VFS is in the process of constant change. The dynamism becomes weak in the BES and ceases to operate in the Bangar. The locational niches of the area in the BES may have static character or the dynamism operates through some variable other than the Khadar habitat system.

This is not to say that all the locational niches in the VFS are the response of the habitat system alone. Factors external to the Khadar eco-system, or some other variable of the eco-system may have a modifying influence on locational niches. Final choice of a niche depends on human decision. A decision of an administration to establish a new settlement may be based purely on economic grounds or on the availability of space and may not be related to the habitat at all. Usually such settlements are forest or mining camps, *e.g.*, a small forest camp in the forest zone of the Hastinapur Khola in Mawana. The resettlement of Bhadwi [(G-044) (Figure 6.2)] along the Ganga channel in the VFS of the area was a political decision in 1971 to rehabilitate the displaced persons from the erstwhile East Pakistan. Sometimes the administrative decision and the habitat systems may cross each other. Thus, the main settlement of Latira [(G-131) (Figure 2.5)] is located East of the main channel of the Ganga in Bijnore Tehsil. As the channel swings back and forth, one or more hamlets of the village appear in Hapur. They retreat to Bijnore when the channel shifts westwards.

The road may be a powerful factor superimposed on the habitat system in setting character of the locational niches. Laying of road is generally a political or administrative decision though may be based on some economic or social factors. Actual layout of a road has to be related to some variables of the prevailing habitat system and is laid over the embankments in the Khadar environment in creating the positive locational niches for settlements. An altogether new settlement may appear in the VFS or the BES if a new road is opened in the area. Thus, many hamlets of Malipur (Daulatpur or Malipur, G-032 in Figure 6.2) have come up recently in association with the State high-way between Meerut and Bijnore running through the Ganga Khadar. Goripur (Y-020)

along the Yamuna had to vacate the previous locational niche (Khera) due to the encroaching meander and the present location runs along Delhi-Saharanpur highway. The settlement of Bridgeghat is located where buses plying on the national highway halt at the crossing of the Ganga. The settlement was called Bridge-halt in the 1951 Census. Most of the dwellings of the settlement in Bridgeghat are commercial or religious, associated with the religious bathing at the Ganga

The bands of the chosen locational niches are generally set by the environmental gradient. There in a single set of the occupied niches in the VFS of medium series, which may more than double in the extended series (Figures 6.2 and 4.1). The VFS of the truncated series is too narrow to provide the chosen niches for settlements. The BES of all the series has at least one set of the chosen niches, but the superimposed series may have satellite *majaras* in the VFS though main village remains perched in the BES. Man may choose not to occupy a positive niche, *e g.*, in Bagarpur (G-137) near Garh (Figure 2.6) in the modified series, or may have occupied niches in the natural negative areas, *e.g.*, in a depression South of Loni (Y-046) at Delhi border along the Yamuna (Ghaziabad). Location of the chosen niches in different series is hypothesised in Figure 7.1.

5. THE CONCLUSION

The settlements are a complex variable of the Khadar environment involving man. *It has the functional niche (Watts)*[1] *to provide the energy parameter needed to run the eco-system involving man.* The energy runs in and out through the dwellings as hardware and over the circulation lines as *likis*, *dagarhas* and roads. An inter-play of the dwellings and the circulation lines is studied as the lower order settlement system and a variable of the eco-system. At the same time a settlement can also be viewed as the combined output of all the variables of Khadar eco-system. As such, settlement is the output of Khadar eco-system.

1. *Ibid.*, Watts, D., (1971), *Principles of Biogeography : An Introduction to the Functional Mechanisms of Eco-systems.*

A settlement as the environmental variable has the component of energy storage and energy circulation. The former component is measured as the variable attributes of the dwellings, the second as the variable attributes of the circulation lines *viz.*, *likis*, *dagarhas* and roads. Greater storage, higher capacity and greater storage expansion prevails under the BES with urban shadow, compensated by scant storage, limited capacity and the absence of expansion in the valley flat along a channel under the VFS. The compensating interaction sets the functioning of the settlement system. Thus, man raises his dwelling at the Bangar edge but descends to valley flat to complete his interaction with the environment. The output of the system is either the fully integrated extended series, or partially integrated medium series ; or the incomplete truncated series.

A settlement combines the output of all the environmental variables as the combined output of the Khadar eco-system. Thereby *settlement of a particular type is the state in which Khadar eco-system of man can be at a given time and place.* There are large settlements with more than 200 houses in the inverted communities at wet points under BES, medium settlements with 100 to 150 houses in the normal communities at partly dry and wet points under the BES and the VFS, and small settlements with less than 100 houses in the truncated communities under the VFS. The three states prevail simultaneously at different spatial segments of the environment interwoven together as one complex eco-system of the Khadar environment.

7

Summary and Conclusions

1. THE INTRODUCTION

Rural ecology is a study of human eco-system focused on man (Chapter 1). Eco-system is a high order system where some low order systems are nested within it as its variables. The preceding chapters bring out the variables of the Khadar eco-system as open systems. This chapter presents the Khadar eco-system as a unified system on the basis of the previous chapters. The section on the summary brings out the salient attributes of the individual variables and the relationship among these variables. The section on the conclusion highlights the attributes common to the unified eco-system. The epilogue is the resume of the work.

2. THE SUMMARY

The rural ecology of active flood plains the Khadar tract s of Meerut district is the study of the human eco-system located in the Khadar environment of the erstwhile Meerut district. The *Khadar the channel environment is identified by actual or potential inundation related to flow* (Chapter 1). The habitat and biota are the simple variables of the eco-system while man is a complex variable [Figure 7.1(A)]. The complexity is caused by multi-faceted nature of man. On the one hand, man presents two tiered organisation at population and community levels as the two variables of the eco-system. On the other hand, man also represents the energy in circulation and at rest needed to run the eco-system. Man gives surface expression to the energy in the form of the settlement system as a variable of the eco-system. In addition, settlement system represents

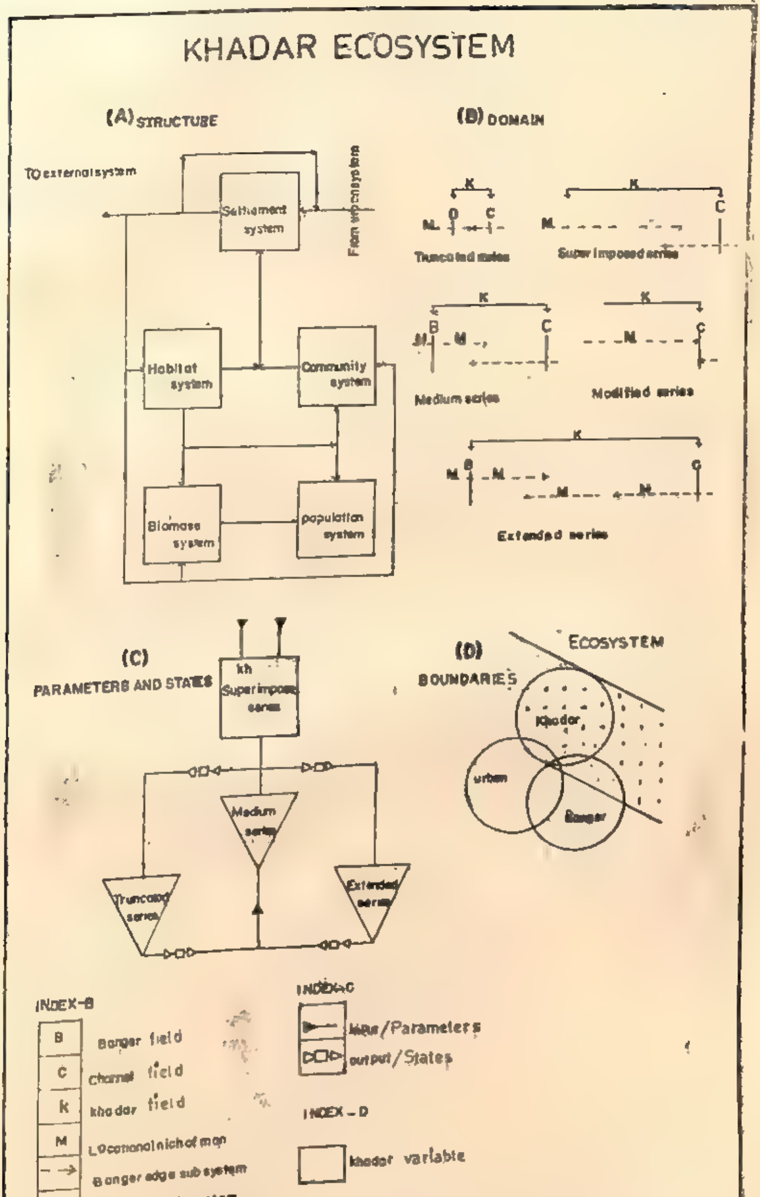


Fig-7.1

the out-put of the Khadar eco-system. Each component system has a set of the inputs or parameters, the elements or variables and the out-put or states.

The habitat system is the inorganic variable of the Khadar eco-system (Chapter 2). The energy flow and the matter to be worked upon by the flow are the given parameters of the habitat system. The energy moves through the channel flow, resulting in the fluvial action ; and as the Bangar flows resulting in the mass wasting. Super-imposed on the two is the biochemical energy of organisms, *viz.*, man, modifying the results of the fluvial action and mass wasting. The energy acts upon the matter provided by the alluvium filled gangetic trough edging and the underlining the Khadar habitat as the neighbouring Bangar.

The variable of the habitat system is the organisation of the K-field [*Figure 7.1*(*B*)] *operated by the Khadar processes.* A field is a surface where every point on it is operated by a common process, *e g.*, the Khadar process.[1] The *K*-field is bounded by the *C* or channel field on one side and the *B* or Bangar field on the other. Interactions of *K* and *C*-fields produce the valley flat sub-system, VFS, while the interactions of *K* and *B*-fields produce the Bangar edge sub-system, BES, both as the sub-fields of the *K*-field [Figure 7.1(B)]. The VFS is dominated by the fluvial action associated with fluvial energy while the BES is largely the manifestation of the mass wasting. The interplay of the energy results in characteristic habitats zones parallel to a channel. These zones, from channel to Bangar, are valley flat divided into lower, central and upper parts depending on their relative heights from channel surface ; trough zone indicating termination of the VES and the beginning of the BES ; toe slopes as the sudden increase of elevation with steep slopes ; Khola zone as land of broken topography ; and the Bangar edge as segment of Bangar with the potential for extension of the VFS. All the habitat zones are the spatial segments of the Khadar environment.

The output of the habitat system is the variable aggregate of the habitat zones. These aggregates are called the Khadar series [*Figure 7.1*(*C*)]. The Khadar habitat that includes each of the landform zone with a single valley flat forms the medium series. The habitat where valley flat is extended into lower, central and upper parts, marked by the features of the abandoned channel, forms the extended series. The missing of a valley flat results in the truncated series.

1. Based on Lucas, J.R. 1984. *Space, Time and Causality, An Essay in Natural Philosophy.* Clarendon Press, Oxford.

Each of these series has the additional attribute of the locational niches for man, M with respect to the habitat zones [*Figure 7.1*(*B*)]. Man is invariably located in the Bangar edge but a medium series has the additional location in the zone of the single valley flat. The valley flat of the extended series has more than one set of the locational niches for man. The valley flat is either missing or too narrow to provide the location of man in the truncated series. The locational niche of a man may be located far away from the *K*-field in the Bangar resulting in the superimposed series of the habitat system.

Each of the series and the included locational niches have their own attribute of inundation. The moderate series has a moderate extent of inundation prone niches while the extended series has more of them extended over different valley flats. The truncated series lack the inundation prone niches as *K*-field is truncated but has high potential for converting the area under the BES to the VFS. The superimposed series has extensive inundation free niches. In addition to these, dominance of the biotic processes can modify the *K*-field to the extent that either the characteristic zones are missing or are present where they are not expected in the natural run of the system. The habitat system with such an output forms the modified series.

The locational niche is one of the given parameters of the biotic system (Chapter 3, Figure 3.1) focused on the plants and the accompanying animals. These niches are classified as ill, excessively or moderately drained located within the *K*-field relative to the dispersal of plants and animals. The period of inundation over the ill-drained niches is longer than the inundation free period. The inundating water may be stagnating or moving forming the areas of water logging or water flow. The excessively drained niches are drained only when over-run by a sheet of water moving down the slopes but are otherwise inundation free. The moderately drained niches are inundated for a period less than the period free of inundation. Other inputs of the biomass system are the matter as plants and animals and the biochemical energy required for the growth cycle of the organisms.

The biotic system is composed of the biomass communities, *i.e.*, the plant associations and the related animals. A plant associa-

tion is a set of the interdependent plants sharing a given common territory. The plants with their restricted mobility show greater response to the variations in the locational niches than the animals with their greater mobility. The mobility enables the animals to be a part of the environment larger than contained in *K*-field. However, the adjustment of plants to the variations of the locational niches may cause enough environmental changes to bring about changes in the related animals. Thus, the biotic system may be considered as to be composed of a single variable of the plant associations.

The plant associations operate through the mechanism of distribution, chiefly dispersal related to the locational niches. Herbacious plants, *viz.*, grasses, dominate every-where as these alone can occupy the ill-drained niches and the other niches can initially be occupied by them before plants of other life form occupy the niche. *The plant associations keep changing with the changing characteristics of the locational niches* (which in turn change with the dynamics of the habitat system) by succeeding the others through the allogenic plant succession in the VFS and the autogenic succession in the BES.

The natural plant succession can be interrupted by the geomorphic or biotic processes. The geomorphic processes change the external environment and the succession can begin through a different stage. The biotic processes, namely *man*, *terminate a natural plant association, replacing it by the modified plant communities, i.e., cultivated plants.* These associations change periodically as the rabi or winter crop and the kharif or summer crop with the intervening zaidi as the additional crop ; or land is left fallow.

The rabi is dominated by food crops, *viz.*, cereals, wheat may be the crop in the VFS but only a major crop in the BES. Kharif is dominated by sugarcane, along with rice in the VFS and coarse grains in the BES. Non-food crops, *viz.*, fodder is grown during kharif over a larger area under the BES than under the VFS.

The other things being equal, the area under the rabi and kharif crops depends on the availability of water. The areas of regulated water supply, *i.e.*, the irrigated areas, can have some

cultivated crops in all the cropping seasons and show the equality of the area under the rabi and kharif croppings. The areas dependent on natural water supply, *i.e.*, unirrigated land of the Khola zone may suffer from the physiological drought during the rabi so that the acreage becomes less than that of the kharif. Areas under the VFS may be water logged and unable to grow kharif reducing its acreage relative to rabi. In the case of the Ganga Khadar kharif acreage is less than rabi, occasionally dropping to zero in the areas of encroaching meander along the channel in the VFS while kharif acreage in the areas under the BES may rise as much as three times the rabi acreage.

The modified plant communities compete with the natural communities in such a way that they cover about 50 per cent of the total village area and over 60 per cent of the total cultivable area in a village of the VFS. The size increases in the BES to about 80 per cent of the village area and 90 per cent of the total cultivable area. This is combined with the fact that the average yields in the VFS may be one-tenth of those in the BES. *As the VFS is single cropped while the BES is more than double cropped the absolute size of the modified communities is much larger in the BES*, particularly of the superimposed series than in the VFS, particularly in areas of the encroaching meanders.

The output of the biomass system is the spatial variation in the size of the modified communities directly available for man's interactions. The size is measured as the product of the acreage under cultivated area, number of crops in a year and the average yield per unit area. The size varies with the environmental gradient as the three variables combined in the BES are about ten times of that in the villages of the VFS. The other things being equal, the super-imposed series have the largest size with their high yield, multiple cropping and high percentage of cultivated area. The modified plant communities have a smaller size in the truncated series which have a limited areal extent. The extended series with repeated valley flat have the larger cultivated area, therefore, have larger size of modified communities than that of the medium series with a single valley flat. The modified series have unpredictable size of the modified communities as man's intervention may increase or decrease the size unrelated to the environment. (Charley and Kennedy.

2. Charley and Kennedy, B. 1971. *Physical Geography. A systems Approach.* Prentice Hall, London.

The variable size of the modified plant communities is one of the inputs in population system (Chapter 3) focused on the aggregates of the individuals as population clumps. *The modified communities have the capacity to support man setting the carrying capacity of land. The capacity is standardised as one person per acre of cultivated land for* the Khadar tracts of the district on the basis of the prevailing ratios. Man as an individual is the other given parameter. The part of the energy is provided by the stimulus of man for food and other economic wants so that he can move himself from food deficient areas to food surplus areas through migration.

The population clump is the variable of the population system. A clump has the attribute of size measured in one or more dimensions and changes its size through growth processes. *The size measurement in one dimension provides average of 250 persons in the valley flat of the extended series, increasing to about 500 persons in the flat of the medium series.* The average size increases abruptly to over 1000 persons in the BES of all the series except in the truncated series which have the small size of 370 persons. The size can also be measured with the *regional means* as the *trend analysis of the size based on the averages moved over space rather than over time* (Figure 4.3). An average size distribution and the regional means correspond to the environmental gradient set by the habitat system.

A clump size can also be measured in more than one dimension as the arithmetic mean expressed as the number of persons per unit area ; or as the *ecological density* giving the ratio of number of persons per unit of cultivated area. *In the Khadar environment one person tends to have less than one acre of the cultivated land.* therefore, the ecological density is more conveniently expressed as the acres of cultivated area per person with reference to the carrying capacity of land. *The villages under the VFS provide more than ten acres of the cultivated land per person though the ratio drops as low as 0.2 acre per person in some villages of the BES.* Thus, the ecological density is low in the VFS, particularly in the villages of a meander encroachment and it is high in the BES, particularly in the villages which shelter man from the

villages of a meander encroachment. These are called shelter villages.

A clump size increases with time through the variable growth rates The growth itself is dependent on the sub-systems of natural growth and migration factor. Natural growth has parameters of sex composition and age structure, apart from many other parameters expressed in the life tables. The parameters are such that *there is an average of seven persons per family in the Khadar tracts* though the size is much smaller in the VFS and larger in the BES particularly in villages with the urban shadow located along the highways. *Man in the Khadar tracts grows at the average rate of about 2 per cent per annum in the stable populations* growing at a constant rate. However, clumps of many villages are far from being stable. A clump can be depopulated or show rapid decline where a village is covered by a meander encroachment. Man of the depopulated village takes shelter in some Khola village ; or occasionally in a village of the central valley flat. This raises the clump size and growth rate of the *shelter village*. The refugee population returns to its village with recession of the meander creating a new village in the VFS or increasing the growth rate much above the average. At the same time clump size and growth rate of the shelter village is reduced drastically at the shelter village *Differential growth rates, spread over different spatial segments of a Khadar tract, is the growth spectrum* (*Figure 7.4*) which summarises the variable of the clump size in the population system.

The output of the population system is the degree of crowding at a clump with respect to the carrying capacity of land. Theoretically, a clump can be balanced but more often a clump size is over-crowded with size being bigger than that can be supported by the carrying capacity ; or it can be undercrowded where the size is smaller than that is warranted by the carrying capacity. *Undercrowding prevails in the VFS, particularly in the areas of meander encroachments ; and overcrowding is the case in the BES particularly in shelter villages.* Despite the fact that the actual size of the modified communities is much larger in the BES, most of the villages of Bangar edge do not deviate much from the carrying capacity unless they act as shelter villages or interact with the resources other than the local land.

The attribute of crowding is an input in the community system (Chapter 5) of man focused on the differentiated populations sharing a common territory. Such a grouping of populations is a human community. There is some degree of interdependence of some sort among the populations. An energy input needed to organise the interdependence is provided by the stimulus-response system of man. The material wants stimulate man to respond by way of economic interactions differentiating him as general populations of non-workers and workers. The workers themselves have a variable internal structure grouping them into primary or basic, invading and link populations. These population groups are fundamental links in the functioning of the community system, hence called the functional populations.

A set of the functional populations is the variable in the community system. The primary functional population is composed of the cultivators supported by agricultural labourers and dairy workers. They are directly dependent on local resources and are capable of supporting their fundamental material needs if chosen so. They produce surplus to be moved out. Invading populations are composed of the workers in household and cottage industries and the workers in manufacturing. The output of their stimulus responses system is essential for other populations. Link population is composed of the workers in 'other services', in trade and commerce, in transport and communication ; and in construction. They maintain the circulation of energy and matter needed by all the populations.

The three populations organise themselves with a normative distribution ratio to obtain spatial self-sufficiency at the local or village level. The prevailing technology is such that in a village more than half of the total workers are composed of the primary populations while the less than half is shared equally by the invading and link populations. Such a ratio prevails in the villages of the Bangar. More often, there is *regional self-sufficiency where the invading and link populations do not have equal share.* The deficiency in the size of one population is compensated by increase in its size in some other spatial segment, *provided one of the two does not fall to less than one-third the size of the other.* The three functional populations can carry on the required function of the

spatial self-sufficiency spread over the area of the complementary ratios.

The spatial interaction of the areas is such that there can be increase in the size of the basic populations displacing the other populations forming a truncated community organisation ; or the invading or link populations grow to the size that displaces basic populations forming the inverted communities. Truncated communities are structured largely with the primary population while the inverted communities have more than half of the total workers composed of the invading or link populations. The inverted communities may form the industrial centres with the dominance of the invading populations or may be the service centres with the dominance of the link populations. Interaction between the truncated and inverted communities is the community organisation at environmental scale.

The output of the community system varies as the self-sufficient, truncated or inverted communities at local or village level. On the environmental level, community system produces dependence of man on local resources for a balanced local growth ; or interdependence of the truncated and inverted communities for a wider environmental growth.

The output of the community system is the input in the settlement system (Chapter 3) focused on man's dwellings and the interlinking lines of circulation. The dwellings cluster as a settlement, linked through footpaths, cart tracts, unmetalled or metalled roads. The energy parameter is provided by the stimulus responses system of man that stimulates him to raise shelter-structures for himself and for his belongings ; at rest or in motion, along with the lines of circulation. As man is the prime source of energy running an eco-system the settlement system is not only an environmental variable but also the manifestation of energy at rest and in motion. As such, the system operates with the output of all the other environmental variables as the inputs.

The interlinking of the dwellings and their cluster, by the circulation lines is the variable in a settlement system. They act as the two sub-systems of the system, and have their own attributes. The major attribute of the dwellings is the evolution as

a settlement succession continuously operating in the VFS though may occasionally appear in the Khola zone of the BES. The succession begins with the isolated dwelling in a valley flat at the locational niche under possession of a member individual of the basic population. This is common where the clump size is confined to one or two families, though soon there may be member of isolated dwellings located within the fields of different farmers. The control is provided by the modified plant communities which cover at least half of the total village area. As modified communities grow in size, clump size also increases responding to the carrying capacity of land. The structure progresses towards a balanced community inducting the invading or link populations independent of the land resources. Isolated dwellings cluster as hamlets and the control moves to the relative safety against inundation. As community organisation progresses further, increasing the size of non-basic populations, hamlets merge to form a compact settlement located over the niches with maximum safety against inundation.

Meander encroachment may disrupt a settlement succession. New settlement may appear in course of time at a similar locational niche but occupying the different coordinates in the cartesian space.

The succession follows and is followed by the lines of circulation. The initial movement of energy and matter in the form of man and his belongings is limited resulting in the number of footpaths. As the matter to be circulated increases in size with the appearance of a larger cluster of dwellings, circulation develops a more efficient system as cart tracts. The efficiency of the circulation may increase to the status of a metalled road if the required movement of matter has some degree of permanence. Such permanence cannot be expected in a highly dynamic Khadar environment. However, the Khadar may provide passage to a metalled road linking the areas of external environment. Roads lend some degree of permanence to the circulation system and the linked settlement of the passage tends to become more permanent, growing in size that occupies the physical space larger than the average of 2 per cent of the total village area. However, roads, metalled or unmetalled, may also appear to connect the truncated

and inverted communities. As the inverted communities are located in the urban shadow, roads radiate from these areas in the form of an urban shadow.

The output of the settlement system is the variable degree of permanence of man so that he can perpetuate his interaction with the environmental variables of a Khadar tract. Thus, there are sections in a Khadar tract where man is located at the similar niches repeated as more than one band of the settlements in the VFS as in the extended series. The man may raise only a single band of settlements in the VFS forming the medium series but may lack settlements in the VFS forming truncated series ; or has settlements only in the BES, located far away from valley flat, forming the superimposed series. Thus, the settlement system corresponds with the environmental gradient. However, a settlement may transform the habitat to occupy large inundation free area providing them greater and artificial security against inundation. The settlement becomes larger but the habitat is transformed loosing its Khadar attribute of inundation. This happens in the case of an urban settlement, associated with the modified series. Thus, the output of the settlement system summarises the output of the Khadar eco-system which is initially related to the habitat system [Figure 7.1(A)].

3. THE CONCLUSIONS : OTHER ASPECTS OF THE KHADAR ECO-SYSTEM AS A SYSTEM

The man interconnects the variables of the environment under the response-resultant system, RRS. Each human interaction is the element of response in the system. The resultant of one RRS is used as the input of another. A series of RRS may operate over the given spatial segment, such as a village. The part of the resultant in the series may feedback to the interacting man to satisfy his wants as the direct feedback. It is largely composed of the interactions which produce items of foods as by the primary populations. Some of the resultant in the series of response-resultant system must move out to another spatial segment within the same environment or in the other environment before feeding back to satisfy human wants. This is the component of indirect feedback in the set of relationships among

the variable of the eco-system. It is largely associated with the invading and link populations. Direct feedback is widespread in the valley flat sub-system and the indirect feedback dominates the BES necessitating some complementary interactions.

The Khadar eco-system is perceived as centred at the Khadar environment interacting with the neighbouring Bangar as the marginal environment. The two share a common social space of the rural environment. This in turn interacts with the social space that is external to the environment of the eco-system *viz.*, urban.

The eco-system has well defined *boundaries* (Harvey[3]) for the domain of the Khadar environment. It is confined to the variables of habitat, biota, man at population and at community levels and his settlements. The variables have the physical boundaries coinciding with those of the habitat system (Chapter 2, Section V). A channel forms the physical boundary on one side [*C* in Figure 7.1 (B)]. However, channel is not a habitat of man and as such there is no fresh water eco-system of man. The Khadar habitat and the Khadar eco-system prevails on either side of a channel, one assumed to be mirror image of the other (Chapter 1).

The Bangar provides the physical boundary of the Khadar eco-system [*B* in Figure 7.1(B)]. On the other hand, however, mobility of man allows the eco-system of man to extend much beyond the areas of their immediate physical proximity. The interaction of Bangar and Khadar eco-systems produces the ecotone of the Bangar edge sub-system studied in the previous chapters. The mobility of man and his interactions may be such as to eliminate a habitat system from the environmental variables of an eco-system. Thus, the boundaries of eco-systems based on habitats may merge together without a perceptible ecotone. The boundaries involving man require a demarcation on the basis of the differentiated populations of man. These are perceived as the functional boundaries.

The *functional boundaries* of the Khadar eco-system are located where a typical Khadar community changes to some other

3. Harvey, *ibid*.

community structures. It may be recalled that the Khadar communities are dominated by the primary or the basic populations where their proportionate size is more than 70 per cent of the total workers (Chapter 5). The structure changes in the villages of the BES where the basic populations form less than 70 per cent of the total workers. Such a difference in the ratio can be used to demarcate the rural Khadar and the rural Bangar eco-systems. The size of the basic populations drops to zero or less than 50 per cent of the total workers in the urban areas or the areas of urban shadow. This is the demarcating line between the urban eco-system and the rural eco-systems, whether Khadar or Bangar. Thus, the Khadar eco-system shares its boundaries with the Bangar of the common rural environment ; and with an urban eco-system from the external environment [Figure 7.1(D)].

The eco-system can operate at more than one *scale, viz.*, organismic, local and environmental. Organismic scale is the lowest, centred on the individual man. Many parameters of the eco-system do not exhibit any noticeable response at this level. Moreover, an individual can interact only in one way at a time so that he displays only partial organisation of the eco-system. In the case of the stimulus-response system entire family rather than an individual as unit responds to the given parameters making it difficult to differentiate the individual from his family. Thus, the eco-system at the organismic scale is not only partial but also indistinct.

The higher than the organismic is the local scale of the eco-system. It operates at the village as a unit. A village can clearly show response to all the given parameters of the eco-system. The responding individuals are stationed at the built up area of a census village but the interactions are assumed to extend over the entire village area. A single village can display only one of the possible states in which the eco-system or its component variables can be. Despite this drawback, local scale of the eco-system offers the best scope for studying the mechanism that leads to one of the possible states of a system. The variables of the Khadar eco-system have been studied at village level throughout the present research work to formulate the human ecosystems (Chapman).[4]

4. Chapman, G.P. 1977. *Human and Environmental Systems. A Geographer's Appraisal*. Academic Press, London.

The environmental scale is of the highest order in the study of the eco-system. It is based on the collection of villages located in different spatial segments of the environments, *i.e.*, the villages of different habitat zones. Generalisations at this scale are either in the form of summary statistics for the environmental segment containing all the habitat zones or may give the trend along the environmental gradient. The village level study of human has been used throughout to express the average value of the environment in a tract as well as along the trend line along the gradient. It may be noticed that the environmental scale cannot be derived without use of the village level analysis. All the possible outputs of the eco-system and the values of its environmental variables are displayed at this level. The Khadar series and the environmental gradient itself is based on the study at this scale.

The natural Khadar eco-system is a *homaeostatic* type system, Such systems resist any alteration in the environmental conditions and exhibit a gradual return to equilibrium or steady state behaviour after such an alteration (Walmsley).[5] The steady state in the Khadar eco-system represented by the medium series has a moderate extent of physical space of human interactions. The extended series is gradually reduced by a meander sweep tending it towards the medium series while the truncated series is built up by adding a wider valley flat tending it towards the medium series. Such a homaeostatic system contains a negative feedback mechanism to enable them to return to the equilibrium or steady state. Therefore, larger the original disturbance, as under the truncated or the extended series, larger is the force exerted in returning the system to the steady state. However, the Khadar eco-system of man is an adaptive system as there exist for each possible input a set of one or more preferred states, or preferred outputs. The preferred state for the Khadar eco-system is to keep inundation to a minimum by raising embankments, diverting channels or by any other method.

The Khadar eco-system can be in different *states* as the *output* [Figure 7.1(C)]. A state represents the degree of interdependence among the variables based on the energy flow in the eco-system. It is assumed that size of the energy circulation is adjusted to the

5. Walmsley, *op. cit.*

energy requirement. The requirement itself is dependent on the spatial variations among the variables. The variations would be maximum in a series which contains all the possible habitat zones or locational niches favouring or inhibiting man's dispersal. This is the case of the extended series containing a valley flat with the double band of the energy at rest [M in Figure 7.1(B)]. A single band forms the medium series while the absence of it forms the truncated Khadar series. Thus, the output of the Khadar eco-system corresponds with that of the settlement system.

The *output* can be graded along the environmental gradient with medium series in the middle; extended at the higher level and truncated series at the lower level. The gradient corresponds with the potential of inundation, therefore, the spatial segments under the series can be further graded accordingly. The environmental gradient is lowest at the Bangar edge where the eco-system has the most obscure functioning. The gradient rises at the central valley flat, *e.g.*, at the middle terrace of the Ganga to the trough zone, keeping the upward trend at the valley flat with receding meanders. It is the highest at the valley flat along the channel where a meander loop is encroaching. It may be noticed that the spatial sequence of the zones is rearranged for the gradient. The central valley flat forms the exception in the spatial sequence used in the preceding chapters.

The superimposed series of the Khadar environment is the *ecotone* of the Khadar eco-system. It represents the transition between the two eco-systems located over two different habitats though the social space remains unchanged. It is the transition between the rural Khadar and the rual Bangar environments. It may also act as the ecotone between the segments under two social spaces, *viz.*, urban and rural. Villages of the superimposed series located at the Bangar urban fringe and along the circulation lines between the urban and the rural areas, would represent the ecotone in social space as the urban shadow.

The actions of man beyond a certain limit acts as the *disturbance* in the normal Khadar eco-system of man. It can lead to modification of the Khadar eco-system as the modified Khadar series of the environment. The eco-system is said to be modified

either where it occupies the physical space between *C* and *B* fields [Figure 7.1(B)], but lacks the characteristic attributes of the Khadar habitat; or where the attributes of the Khadar habitat are present without the bounding physical space of *C* and *B* fields. In either case, the functioning of some variables is missing or is over represented. In the former case the modification leads to sub-Khadar eco-system and in the latter case it results in *pseudo*-Khadar eco-system. The sub-Khadar operates where man has blocked or diverted the channel flow, *e.g.*, along the railway line crossing the Ganga near Garhmukteshwar or along the highway between Mawana and Bijnore towns crossing the northern Ganga Khadar. The habitat may be so modified as to eliminate the functioning of the eco-system as in the tract South of Ghaziabad town along the Hindon. The psuedo-Khadar results from inundation or waterlogging directly unrelated to the channel flow. It can be located in any low lying area with poor drainage, such as the one underlain by clay pan, *e.g.*, in southern Ghaziabad, between Delhi and Ghaziabad towns.

4. THE EPILOGUE

The human ecology of the Khadar tracts of Meerut district provides scant information about the unique case of the three Khadar tracts located in the erstwhile district of Meerut. It lacks factual details as the Khadar tracts are treated as the samples of the Khadar environment in general. This makes it possible to draw generalisations based on logic and matched with empirical findings. This has enabled generalisations to be presented in a theory form, even though lacking the refinement of a calculus. All the definitions are not rigorously structured with the primitive terms, however, rigorous definitions have been used where they were essential for the clarity of the concept incorporating them.

The present work has been a research in methodology rather than the presentation of factual details. The methodology used draws inspiration from Hawley and MacKenzie who have done the pioneer work in human ecology and from Odum's work showing concentrated effort in methodology and techniques employed in the study of an eco-system.[6] It deviates from the

6. Inspired by Stoddard D.R. 1972. 'Geography and Geological approach': in Davis, W.K D. (Ed.) *The Conceptual Geological Revolution in Geography*. Rowman and Littlefield, pp. 301-311.

common line by overstepping structure-function diachotomy or synthesis. The methodology adopted follows Margalef who treats an eco-system as a system requiring systems analysis. It omits any reference of structure and function of the eco-system but requires the study of variables and their relationships which function together as a system on some chosen scale.

The methodological work remains incomplete without the mathematical presentation of the theoretical structure. Because of this the level of information gained[7] has not been measured. The present work concentrates on establishing the methodological framework for the study of human eco-system, it is hoped that the future study can give the mathematical structures leading to suitable modifications of the generalisations presented here.

It may be noticed that the methodology used in the present case uses *ergodic hypothesis* based on space-time transformations as the technique of ecological succession common in the ecological studies. The stages in a process are resurrected hypothetically by logically linking one spatial situation to another located in the same time space. The technique has been used to study the evolution of the Khadar landform in the Khadar tracts, the process of migration to and from the shelter villages, the evolution of the community structures; and of the settlement structure, apart from the usual study of the ecological succession of the plant associations. The technique has helped in evolving the urban shadow as a distinct spatial force.

Throughout the study there has been emphasis on the spatial attributes of ecology. Space-time transformation itself is based on the spatial attributes used for projecting the future trends, expressed as the spatial trend line (Chapter 3). Incorporation of the spatial attributes brings out the facts that the study of ecology is a branch of geography that studies the spatial organisations. The ecological approach is a synthesis of the traditional branches of geography.

One of the variables of the synthesis on the present study is the habitat system. It can be interpreted as a study in environmentalism if the word environment is taken in the restricted meaning

7. In the form of entropy.

of terrain or landform. Undoubtedly any ecological study is a study of relationships between man and environment, therefore, a study in environmentalism. Environment is defined in ecology as a set of the chosen variables. In the present study, one of the chosen variables of the environment happens to be the habitat system but it need not essentially be a variable in all the eco-systems involving man. It is hoped that the study of any human eco-systems located over other locational framework can be guided by the present study :

Man, like the habitat, is another chosen environmental variable to evolve a natural eco-system of man. He is as much an integral part of the eco-system as plants in a plant eco-system. The integration is expressed in a medium series. The natural balance is disturbed by overactions of man. Frequently known as the environmetal degradation the imbalance in this thesis has been expressed as a modified series. It is hoped that the demarcation line can be used for a future planning for the best results.

Appendices

APPENDIX A

Table 1.1. Village Code Numbers and Names

Code No.	Name	Code No.	Name
R. Ganga, G		G—021	Parsapur/ Hansapur
Mawana		G—022	Ropra
G—001	Bela	G—023	Bamnaula
G—002	Bhuwa	G—024	Bamnauli
G—003	Bhagupur	G—025	Rithaura Khurd
G—004	Fatehpur Prem	G—026	Gajrauli
G—005	Manpur	G—027	Nagli Khadar
G—006	Chamrod	G—028	Mahmoodpur Sikera
G—007	Sujjatpur	G—029	Birkhera
G—008	Tarapur	G—030	Hastinapur Kauravan
G—009	Fazalpur	G—031	Hastinapur Pandwan
G—010	Saifpur Firozmohanpur	G—032	Daulatpur/Malipur
G—011	Sarai Khadar	G—033	Aidalpur
G—012	Jalalpur Raunakali	G—034	Kankar Khera
G—013	Jamalpur Meghraj	G—035	Kishanpur Khadar
G—014	Mohammadpur Kheri	G—036	Gokalpur
G—415	Shahpur Sultanpur	G—037	Bahbalpur
G—016	Kunhera	G—038	Surjeypur
G—017	Rithaura Kalan	G—039	Lalpur
G—018	Dabkheri	G—040	Hadipur Gaonri
G—019	Haripur		
G—020	Sherpur		

(*Contd.*)

Table 1.1 (*Contd.*)

Code No.	*Name*	*Code No.*	*Name*
G—041	Jamalpur Khadar	G—075	Gudha
G—042	Manoharpur	G—076	Nagli Gosain
G—043	Shahpur Khadar	G—077	Hadupura
G—044	Budhwi	G—078	Mirzapur
G—045	Bhikund/ Rustampur	G—079	Akbarpur Khadar
G—046	Latifpur	G—080	Aidalpur
G—047	Jharaka	G—081	Agwanpur
G—048	Pathanpura	G—082	Neemka
G—049	Jalalpur Maqbolpur	G—083	Muzzafarpur Khunti
G—050	Paharpur Qutub	G—084	Baghpur
G—051	Khirjapur	G—085	Mirpur Sadho Nagla
G—052	Budhwa	G—086	Kharkali
G—053	Kheri Kalan	G—087	Khanpur Garhi
G—054	Kheri Khurd	G—088	Tarbiatpur Shumali
G—055	Dudhli Khadar	G—089	Mahmudabad
G—056	Seemla	G—090	Narangpur
G—057	Gajupura	G—091	Asifabad
G—058	Saifpur/ Karamchandpur	G—092	Shamshpur
G—059	Ikwara	G—093	Shahbad Garhi
G—060	Bastura Narang	G—094	Sultanpur Dabal
G—061	Paharpur Ram	G—095	Tarbiatpur Janubi
G—062	Makhdoompur	G—096	Gesupur Shumali
G—063	Bazampur	G—097	Gesupur Janubi
G—064	Mamipur	G—098	Kiritpur
G—065	Khore Ahir	G—099	Badshahpur
G—066	Khore Rai	G—100	Saidullapur
G—067	Dayalpur	G—101	Ibrahimpur
G—068	Alipur Morna	G—102	Shahipur
G—069	Kishoripur	G—103	Sikandarpur
G—070	Dupedi Chao	G—104	Bhagwanpur Khadar
G—071	Jalalpur Zora	G—105	Firozpur
G—072	Akbarpur Garhi	G—106	Khanwala
G—073	Akbarpur Ichhabad	G—107	Saloo Rasulpur Panah
G—074	Humayunpur		

(*Contd.*)

Table 1.1 (*Contd.*)

Code No	*Name*	*Code No.*	*Name*
G—108	Asilpur	G—137	Bagarpur
G—109	Alipur Sarangpur	G—138	Sikandarpur
G—110	Aksaripur	G—139	Mohiuddinpur Chitaura/ Gangdaspur
G—111	Chandpur	G—140	Alamgirpur
G—112	Bhagupur	G—141	Palwara
G—113	Mishripur	G—142	Mohammadpur
Hapur		G—143	Salahabad
G—114	Kutubpur	G—144	Paswara
G—115	Khanpur/ Makhanpur	G—145	Alamnagar
G—116	Jamalpur	G—146	Nawada
G—117	Saidpur	G—147	Pooth
G—118	Jharina	G—148	Kant/Shakartila
G—119	Mokimpur	G—149	Kirawali
G—120	Alampur/ Parshadipur	G—150	Reharwa
G—121	Alampur/ Bhagwantpur	*R. Yamuna, Y*	
G—122	Aldadpur/Kolpur	*Baghpat*	
G—123	Kalyanpur	Y—001	Tanda
G—124	Inayatpur Nayagaon	Y—002	Nangal
G—125	Rawasan/Sheogarh	Y—003	Kuri
G—126	Kothla	Y—004	Chhaprauli T.A.
G—127	Shahpur Chaudhari	Y—005	Chhaprauli Rural
G—128	Abdullapur	Y—006	Badarkha
G—129	Shakarpur	Y—007	Kakor
G—130	Rampur/ Niamatipur	Y—008	Shabaga
G—131	Latira	Y—009	Jagos
G—132	Gadawali	Y—010	Kotaka
G—133	Garh Rural	Y—011	Akbarpur Thaska
G—134	Allahabaxpur	Y—012	Kheri Padhan
G—135	Bhakhtawarpur/ Nayabans	Y—013	Luhari
G—136	Bridge Ghat	Y—014	Rajpur Khanpur
		Y—015	Khera Islampur
		Y—016	Sultanpur Hatana
		Y—017	Faizpur Ninana
		Y—018	Faizullapur
		Y—019	Nethla

(*Contd.*)

Table 1.1. (*Contd.*)

Code No.	*Name*	*Code No.*	*Name*
Y—020	Goripur	Y—049	Dharoti Khurd
Y—021	Niwara	Y—050	Behta Hajipur
Y—022	Sisana	*R. Hindon, H*	
Y—023	Khandwari	H—001	Kalina (M)[1]
Y—024	Baghpat Rural	H—002	Kheri Kalina (M)
Y—025	Pali	H—003	Hasanpur Razapur (M)
Y—026	Katha		
Y—027	Nagla Bahlolpur	H—004	Galetha (S)[2]
Y—028	Mavi Kalan	H—005	Kathwari (M)
Y—029	Sankrod	H—006	Jataula (M)
Y—030	Fakarpur Viran	H—007	Zanuddin Chirchita (S)
Y—031	Qutubpur Viran		
Y—032	Mirpur Khalsa	H—008	Kanoni (M)
Y—033	Noorpur Muzabita	H—009	Rasulpur Zahid (M)
Y—034	Abdullapur		
Y—035	Subhanpur	H—010	Mavi Kalan (S)
Ghaziabad		H—011	Uksia (M)
Y—036	Alipur Songerpur	H—012	Kalyanpur (M)
Y—037	Nauraspur	H—013	Mavi Khurd (B)[3]
Y—038	Mirpur Hindu	H—014	Alamgirpur (M)
Y—039	Pachhaira	H—015	Ukleena (M)
Y—040	Badarpur	H—016	Pura (B)
Y—041	Harampur	H—017	Behrampur Khas (M)
Y—042	Latifullapur Nawada	H—018	Behrampur Morna (M)
Y—043	Khanpur Zabti		
Y—044	Haqiqatpur Khudabans	H—019	Hariakhera (B)
Y—045	Ilaichipur	H—020	Mohommadpur Dhumi (M)
Y—046	Loni	H—021	Rawa (M)
Y—047	Saidullabad	H—022	Dilaura (M)
Y—048	Ahmadnagar Nawada	H—023	Amirpur Baleni (B)

(*Contd.*)

1. M, Meerut.
2. S, Sardhana
3. B. Baghpat

Table 1.1 (*Contd.*)

Code No.	*Name*	*Code No.*	*Name*
H—024	Bakarpur Baleni (B)	H—050	Reore Rewra (G)
		H—051	Hussainpur (G)
H—025	Habibpur Nagla (B)	H—052	Sultanpur Chhajjupur (G)
H—026	Mirpur Jharka (M)	H—053	Manoli (G)
H—027	Sikri (M)	H—054	Bhadoli (G)
H—028	Nanu Fatehpur (M)	H—055	Sarora Salempur (G)
H—029	Daulcha (B)	H—056	Bahadurpur (G)
H—030	Ghatauli (B)	H—057	Muthreypur (G)
H—031	Mataur (G)[4]	H—058	Ahmadnagar Nayabans (G)
H—032	Mohammadpur Amad Baghpat (G)	H—059	Afzalnagar Siti (G)
H—033	Mukari (B)		
H—034	Harsiya (B)	H—060	Mahmudpur (G)
H—035	Kunhera (G)	H—061	Champatnagar (G)
H—036	Chamrawal (B)	H—062	Shamshpur (G)
H—037	Laliyana (B)	H—063	Nagla Firozmohanpur (G)
H—038	Alapur (G)		
H—039	Surana (G)		
H—040	Shabanpur Baroli (B)	H—064	Bhanera (G)
		H—065	Asalatpur Faruknagar (G)
H—041	Sothari (G)		
H—042	Gauna (B)	H—066	Ataur (G)
H—043	Singoli Taga (B)	H—067	Morti (G)
H—044	Alamgirpur Tukali (B)	H—068	Meola Agri (G)
		H—069	Arthala (G)
H—045	Sharafabad (B)	H—070	Kaila (G)
H—046	Nekpur Sabitnagar (G)	H—071	Mohiuddinpur Kinauni (G)
H—047	Bihang (G)		
H—048	Puranpur Nawada (B)	H—072	Chhajarsi (G)
		H—073	Mirzapur (G)
H—049	Garhi Kalanjari (B)	H—074	Akbarpur-Behrampur (G)

(*Contd*)

4. G, Ghaziabad

APPENDIX B

Table 3.1 : Area under Forest as Per Cent of Total Area, 1971

Sl. No.	*Code No.*	*Village**	*Area*
1	*2*	*3*	*4*
A. Bangar Edge-Khola Zone			
Extended Series			
1.	G—075	Gudha (R)	14.94
2.	G—074	Humayunpur (R)	10.13
3.	G—073	Akbarpur-Ichhabad (R)	12.19
4.	G—072	Akbarpur Garhi	6 06
5.	G—068	Alipur Morna (R)	12.89
6.	G—067	Dayalpur (R)	17.35
7.	G—065	Khore Ahir	36.86
8.	G—066	Khore Rai	15.52
9.	G—029	Bir Khera	22.78
10.	G—028	Mohd. pur Sikera	42.17
11.	G—014	Mohd. Kheri	28.48
12.	G—012	Jalalpur Raunkali	47.81
13.	G—030	Hastinapur Kaurawan (R)	0.20
Medium Series			
14.	G—138	Sikandarpur (R)	0.14
15.	G—139	Chitaura	1.83
16.	G—117	Saidpur	3.31
B. Trough Zone-Valley Flat			
Extended Series			
1.	G—011	Sarai Khadar	2.35
2.	G—056	Seemla	35.39
3.	G—060	Bastura-Narang	1.22
C. Valley Flat Along Channel			
Extended Series			
1.	G—063	Bazampur	9.30
2.	G—071	Jalalpur Zora (R)	9 39
3.	G—077	Hadupura	22.93
4.	G—086	Khar Kali	59.59
5.	G—087	Khanpur Garhi	27.23
6.	G—104	Bhagwanpur-Khadar	28.46
7.	G—121	Alampur-Bhagwantpur	7.63

* Not present in other villages
(R) Pucca Road
Based on Village and Town Directory, District Meerut, Census of India, 1971.

Table 3.2 : Species Diversity of Crops in the Extended Series of the Ganga Khadar Tract Mawana*, 1975+

Sl. No.	Code No.	Village	Percentage of Total Village Area Under Crop: RABI: Wheat/Cereal Total	RABI: Cereal/Rabi Total	RABI: Non-food/Rabi Total	KHARIF: Rice/Cereal Total	KHARIF: Cereal/Kharif Total	KHARIF: Sugarcane/Kharif Total	KHARIF: Non-food/Kharif Total
1	2	3	4	5	6	7	8	9	10
A. Bangar Edge									
1.	G—010	Saifpur Firoz-mohanpur	94.00	92.00	4.10	91.21	16.89	68.26	14.84
2.	G—075	Gudha	97.99	87.9	2.6	17.56	6 81	42.90	31.86
3.	G—081	Agwanpur	92.6	79.6	8.0	10.08	24.68	52 51	23.28
4.	G—074	Humayunpur	99.8	87.4	7.2	—	12.26	64.90	22.83
5.	G—073	Akbarpur Ichhabad	100.0	97.1	2.1	5.88	5.26	65.63	29.10
6.	G—096	Gesupur Shumali	99.1	84.9	11.0	8.58	21.04	49.16	18.24
7.	G—097	Gesupur Janubi	99.8	83.9	1.5	18.88	19.81	60.18	19.63
B. Khola Zone									
8.	G—030	Bir Khera	100.0	75.0	04.1	3.84	6.37	47.79	45.83
9.	G—013	Jamalpur Meghraj	88.0	83.3	03.6	100.00	1.26	38.23	59.66
10.	G—106	Khanwala	—	—	—	10 40	55.55	38.66	05.32
11.	G—012	Jalalpur Raunakali	98.0	67.2	2.6	76.47	5.51	52.59	49.90

(Contd.)

* Locational niches elsewhere absent or indistinct or data not available
+ Based on the revenue records at Tehsil headquarters.

Table 3.2 (*Contd.*)

1	2	3	4	5	6	7	8	9	10
12.	G—028	Mohmoodpur Sikera	97.5	88.4	2.6	4.78	70.85	21.55	01.99
13.	G—098	Kiritpur	80.0	100.0	—	25.0	26.84	42.28	30.87
14.	G—082	Nimka	83.5	87.0	8.9	8.0	65.85	19.31	13.79
C. Trough Zone									
15.	G—026	Gajrauli	92.0	94.8	2.2	80.0	25.38	51.26	22.84
16.	G—032	Daulatpur Malipur	50.0	62 0	0.7	100.0	58.58	83.08	16.91
17.	G—056	Seemla	79.2	100.0	—	100.0	8.97	87.17	3.84
18.	G—101	Ibrahimpur	100 0	100.0	—	94.28	52.23	26.86	20.80
19.	G—103	Sikandarpur	—	—	—	—	—	—	—
20.	G–084	Baghpur	95.0	100.0	—	100.0	16 10	61.01	14.40
21.	G—049	Jalalpur Maqboolpur	93.5	67.7	32.2	100.0	40.0	51.27	8.72
D. Valley Flat, Central									
22.	G—016	Kunhera	99.0	90 0	96.3	100.0	10.67	66 35	26.68
23.	G—025	Rithaura Khurd	96.0	95.9	4.0	100.0	11.38	84.95	17.47
24.	G—008	Tarapur	96.0	91.2	4.8	84.0	32.43	62.16	14.41
25.	G–009	Fazalpur	100.0	95.0	4.9	71.0	23.72	71.18	5.08
26.	G—045	Rustampur Bhikundpur	94.3	98.8	1.1	100.0	37.38	60.46	2.00
27.	G—034	Kankar Khera	96.0	97.0	2.9	93.33	25.00	52.22	22.77
28.	G—035	Kishanpur Khadar	87.8	97.9	2.0	100.0	28 00	46.00	26.00
29.	G—023	Bamnaula	100.0	95.4	2.2	100.0	12.5	44.85	42.64
30.	G—024	Bamnauli	82.0	95.4	2.3	80.0	20.66	48.76	29.75

1	2	3	4	5	6	7	8	9	10
31.	G—055	Dudhli Khadar	92.6	98.3	0.5	100.0	12.75	82.75	4.48
32.	G—060	Bastura Narang	99.5	94.7	3.3	90.32	13·06	82.16	4.35
33.	G—046	Latifpur	90.9	98 8	0.4	98.03	18.27	66.66	15.05
34.	G—089	Mahmudabad	97.9	100.0	—	—	20.62	51.25	27.50
E. Valley Flat, Receding Meander									
35.	G—064	Mamipur	96.0	97.7	1.0	91.17	35.29	50.17	13.84
36.	G—069	Kishoripur	94.7	94.8	3.7	83.43	37.21	42.0	20.54
37.	G—085	Mırpur Sadhonagla	86.2	91.3	4.3	1.23	46.63	49.76	3.10
38.	G—077	Hadupura	92.0	91.2	2.5	19.04	47.57	44.98	3.88
39.	G—042	Manoharpur	97.5	97.2	0.7	100.0	27.22	67.90	4.87
40.	G—040	Hadipur Gaonri	98.5	98.9	1.5	100.0	29.38	87.83	18.77
41.	G—038	Shirjeypur	95.5	94.0	2.0	60.71	47.72	18.18	31.81
F. Valley Flats Encroaching Meander									
42.	G—001	Bela	98.5	95.6	1.0	100.0	32.98	50.51	16.49
43.	G—002	Bhuwa	97.0	93.9	—	100.0	12.69	52.38	34.92
44.	G—020	Sherpur	94.0	96.3	1.6	84.0	19.45	61.85	18.28
45.	G—044	Bhadwi	96.5	95.1	0 1	98.18	35.48	56.12	8.38
46.	G—052	Bhadwa	85.8	96.0	1.9	100.0	48.34	41.73	9.91
47.	G—021	Parsapur Hansapur	94.0	100 0	—	100.0	12.20	68 60	19.18
48.	G—096	Tarbiatpur Shumali	96.1	92.8	—	89.47	14.70	77.89	2.63

Table 3.3 : Area under Kharif as Per Cent of the Area under Rabi—for Selected Villages, 1975*

Sl No.	*Code No.*	*Village*	*Per Cent*
1	*2*	*3*	*4*
A.	**Bangar Edge**		
1.	G—010	Saifpur Firozmohanpur	2.46
2.	G—014	Mohammadpur Kheri	2.49
3.	G—073	Akbarpur Ichhabad	2.49
4.	G—081	Agwanpur	1.74
5.	G—075	Gudha	2.49
6.	G—074	Humayupur	2.07
B.	**Khola Zone**		
7.	G—029	Birkhera	3.37
8.	G—101	Ibrahimpur	6.70
9.	G—082	Nimka	2.39
C.	**Trough Zone**		
10.	G—084	Baghpur	2.45
11.	G—032	Daulatpur/Malipur	3.20
12.	G—049	Jamalpur/Maqboolpur	4.25
13.	G—056	Seemla	0.76
D.	**Central Valley Flat**		
14.	G—016	Kunhera	0.94
15.	G—034	Kankarkhera	0.83
16.	G—035	Kishanpur Khadar	0.55
17.	G—046	Latifpur	1.83
18.	G—017	Rithaura Kalan	0.66
19.	G—008	Tarapur	2.37
20.	G—023	Bamnaula	1.01
21.	G—024	Bamnauli	0.93
E.	**Valley Flat, Receding Meander**		
22.	G—077	Hadupura	0.49
23.	G—071	Jalalpur Zora	1.51
24.	G—069	Kishoripur	1.21
25.	G—064	Mamipur	1.48
26.	G—085	Mirpur Sadhonagla	1.04
F.	**Valley Flat, Encroaching Meander**		
27.	G—001	Bela	0.58
28.	G—002	Bhuwa	1.97
29.	G—044	Bhadwi	0.64
30.	G—052	Bhadwa	0.42
31.	G—041	Hadipur Gaonri	0.61
32.	G—078	Mirzapur	0.57

*Based on the Revenue Records, Tehsil headquarters.

APPENDIX C

Table 4.1 : Normal Distribution of Population for the Villages in the Valley Flat Sub-system of the Ganga, 1971

Class Interval in Persons, x	*zi*	*Area Under Normal Curve, Ex*	*Area Under Class Interval, cb*	*Expected Frequency, d*	d^2	d^2/E
Zero	—0.8672	0.2244	0.4699	0.0225	0.0005	0.0022
1— 25	0.7935	0.2080	—0.1234	0.0846	0.0071	0.0341
26— 75	0.6460	0.1749	—0.0989	4.0762	0.0058	0.0331
76—100	0.4985	0.4620	0.0370	0.1092	0.0119	0.0813
101—125	0.3510	0.1248	0.0740	0.0508	0.0025	0.0200
126—150	0.2035	0.1090	0.0246	0.0844	0.0071	0.0651
151—175	0.0560	0.1016	0.0617	0.0399	0.0015	0.0147
176—200	0.0914	0.3973	0.0246	0.3727	0.7700	1.9380
201—225	0.2389	0.3885	0.0493	0.3387	0.1147	0.2952
226—250	0.3864	0.3712	0.0493	0.3219	0.1036	0.2790
251—275	0.5339	0.3467	0.0498	0.2974	0.0885	0.2549
276—300	0.6814	0.3166	0.0370	0.2796	0.0781	0.2466
301—325	0.6460	0.3251	0.0123	0.3128	0.0978	0.3008
326—350	0.9764	0.2492	0.0000			
351—375	1.1238	0.2131	0.0246	0.1885	0.0335	0.1665
376—400	1.2713	0.1718	0.0123	0.1658	0.0274	0.1538
401—425	1.4188	0.1476	0.0246	0.1230	0.0151	0.1023
426—450	1.5663	0.1182	0.0000	—	—	—
451—500	—	—	—	—	—	—
501—525	—	—	—	—	—	—
526—550	2.0088	0.0540	0.0123	0.0417	0.0017	0.8314
551—600	3.3097	0.0017	0.0370	0.0353	0.0012	0.0700

Table 4.2 : Poisson Probability Distribution of Proportionate Clump Size, Valley Flat*, Ganga Khadar Tract, 1971+

Total Population = 100 per eent
Number of Observation = 81
∴ n=1.23 per cent

Sl. No.	*Proportionate Size in Per Cent*	*Class Interval in Persons*	*Poisson Probability*	*Expected Number of Villages*	*Observed Number of Villages*
1	*2*	*3*	*4*	*5*	*6*
1.	Zero	Zero	.3592	29.0	21
2.	1.0	1—194	.3239	26.0	33
3.	1.01—2.0	195—388	.2209	16.25	13
4.	2.01—3.0	389—582	.0905	7.0	6
5.	3.01—4.0	583—776	.0356	2.89	4
6.	4.01—5.0	777—970	.0056	0.68	1
7.	5.01—6.0	971—1164	Zero	Zero	3

* Size too large for Poisson distribution elsewhere.

\+ Based on Town and Village Directory, District Meerut, 1971.

Table 4.3 : Regional Means for Selected Areas of the Ganga Khadar Tract, 1971

Sl. No.	*Village*	*Code No.*	*Regional mean in persons*	*Distance from nearest town*
1	*2*	*3*	*4*	*5*
A.	**Extended Series**			
(i)	**Bangar edge**			
1.	Mahmoodpur Sikera	G—028	619	6
2.	Jalalpur/Raunakali	G—012	493	8
3.	Gajupura	G—057	485	3
4.	Ikwara	G—059	442	7
5.	Asifabad	G—091	596	24
6.	Shamshpur	G—092	470	22
7.	Gesupur Shumali	G—096	699	14
8.	Gesupur Janubi	G—097	559	14
9.	Saloo Rasulpur Panah	G—107	351	13
10.	Asilpur	G—108	460	11
	Average		517 persons	
(ii)	**Valley Flat**			
1.	Sherpur	G—020	249	11
2.	Parsapur/Hansapur	G—021	225	10
3.	Rithaura Kalan	G—017	168	8
4.	Kunhera	G—016	354	8
5.	Rithaura Khurd	G—025	254	8
6.	Shahpur/Sultanpur	G—015	234	6
7.	Shirjeypur	G—038	288	13
			251 persons	

(*Contd.*)

Table 4.3 (*Contd.*)

Sl. No.	*Village*	*Code No.*	*Regional mean in person*	*Distance from nearest town*
1	*2*	*3*	*4*	*5*
B.	**Medium Series**			
(i)	**Bangar Edge**			
1.	Alipur Morno	G—068	984	7
2.	Akbarpur Garhi	G—072	1054	9
3.	Humayunpur	G—074	774	8
4.	Gudba	G—075	692	9
5.	Nagla Gosain	G—076	1219	13
6.	Agwanpur	G—081	652	22
7.	Nimka	G—082	1447	22
8.	Baghpur	G—084	929	18
9.	Khore Ahir	G—065	260	8
	Average		890 persons	
1	*2*	*3*	*4*	*5*
(ii)	**Valley Flat**			
1.	Mamipur	G—064	397	11
2.	Kishoripur	G—069	735	11
3.	Jalalpur Zora	G—071	870	13
4.	Hadupura	G—077	124	16
5.	Mirzapur	G—078	1136	18
6.	Akbarpur Khadar	G—079	1173	16
7.	Aidalpur	G—080	1467	14
8.	Alampur/Bhagwantpur	G—121	257	8
9.	Inayatpur/Nayagaon	G—124	346	6
			723 persons	

Table 4.4 : Uninhabited Villages and Habitat Zones

Sl. No.	Name	Code No.	Habitat Zone
1	2	3	4
1.	Dayalpur	G—067	Khola Zone
2.	Khore Ahir	G—065	Khola Zone
3.	Bir Khera	G—029	Khola Zone
4.	Jamalpur/Meghraj	G—013	Khola Zone
5.	Bhuwa	G—002	Channel
6.	Bhagopur	G—003	Channel
7.	Dabkheri	G—018	Central Valley Flat
8.	Bamnaula	G—023	Central Valley Flat
9.	Shahpur/Sultanpur	G—015	Trough Zone
10.	Pathanpura	G—048	Central Valley Flat
11.	Khirjapur	G—051	Central Valley Flat
12.	Paharpur Qutub	G—050	Central Valley Flat
13.	Gokalpur	G—036	Central Valley Flat
14.	Babhalpur	G—037	Central Valley Flat
15.	Jalalpur Khadar	G—041	Trough Zone
16.	Shahpur Khadar	G—043	Trough Zone
17.	Kheri Khurd	G—054	Channel
18.	Seemla	G—056	Trough Zone
19.	Paharpur Ram	G—061	Trough Zone
20.	Makhdumpur	G—062	Channel
21.	Dapedi Chao	G—070	Channel
22.	Akbarpur Khadar	G—079	Channel
23.	Badshahpur	G—099	Khola Zone
24.	Ibrahimpur	G—101	Khola Zone
25.	Khanwala	G—106	Khola Zone
26.	Firozpur	G—105	Trough Zone

(*Contd.*)

Table 4.4 (*Contd.*)

1	2	3	4
27.	Sikandarpur	G—103	Trough Zone
28.	Bhagwanpur Khadar	G—104	Channel
29.	Chandpur	G—111	Trough Zone
30.	Bhogpur	G—112	Channel
31.	Jamalpur	G—116	Khola
32.	Jharina	G—118	Trough Zone
33.	Mokimpur	G—119	Khola
34.	Akbarpur Thaska	Y—011	Khola
35.	Khandwari	Y—023	Bangar Edge
36.	Qutubpur Viran	Y—031	Bangar Edge
37.	Fakarpur Viran	Y—030	Bangar Edge
38.	Haqiqatpur/Khudabans	Y—044	Trough Zone
39.	Sikri	H—027	Bangar Edge

Table 4.5. Life Tables* : (G-086)

(*i*) *Kharkali*

(*a*) Primary Data Inputs as Probability Distributions : for Males (M), Females (F) and Total (T)

Mid	M	F	T	M	F	T	M	F	T	M	F	T
Age Years	l_x	l_x	l_x	L_x	L_x	L_x	T_x	T_x	T_x	e_x	e_x	e_x
1	2	3	4	5	6	7	8	9	10	11	12	13
4.5	.368	.333	.354	.236	.249	.241	2.803	1.622	.807	7.61	4.91	2.27
12.5	.105	.166	.129	.526	.083	.064	2.566	1.381	.566	24.39	8.31	4.38
17.5	.000	.000	.000	.000	.125	.048	2.040	0.498	.502	0.00	—	—
22.5	.000	.250	.096	.105	.208	.144	2.040	0.373	.464	0.00	1 49	4.83
27.5	.210	.166	.193	.183	.083	.144	1.935	0.165	.320	9.21	0.99	1.65
32.5	.157	.000	.096	.078	.000	.148	1.752	0.082	.176	11.16	—	1.83
37.5	.000	.000	.000	.000	.000	.000	1.674	0.082	.128	—	—	—
43.0	.000	.000	.000	.052	.000	.032	1.674	0.082	.128	—	—	—
47.5	.105	.000	.064	.078	.041	.064	0.811	.082	.096	7.72	—	1.5
55	.052	.083	.064	.026	.041	.032	0.026	0.041	.032	0.50	0.49	0.5

* Based on field work, 1975-76

\+ Read the text for explanation of the symbols.

(*Contd.*)

Table 4.5 (*Contd.*)

(*b*) Survivorship, Fertility Table and Stable Age Distribution for Females (Mothers)

Pivotal Age x	l_x	M_x	V_x	$(x)(V_x)$		$(\lambda - x)/x$	C_x
1	*2*	*3*	*4*	*5*		*6*	*7*
17.5	.50	1.33	.665	11.58		.150	.064
22.5	2.00	1.00	2.000	45.00		.427	.183
27.5	0.00	1.00	0.000	00.00	$\therefore G = \frac{290.50}{8.665} = 33.53$ Years	—	—
32.5	1.00	1.50	1.500	48.75	estimated $R_m = .0650$	.107	.046
37.5	1.00	1.50	1.500	56.25	observed $R_m = .0644$	.077	.033
43.0	2.00	1.50	3.000	129.00	$= 1.0715$	.104	.044

(*Contd*)

(ii) **Tarbatatpur Janubi Bagwala** : Primary Data Inputs as Probability Distributions for Males, Females and Total
(a)

Mid Age	M l_x	F l_x	T l_x	M L_x	F L_x	T L_x	M T_x	F T_x	T T_x	M e_x	F e_x	T e_x
1	2	3	4	5	6	7	8	9	10	11	12	13
4.5	.157	.312	.228	.235	.249	.242	.913	.840	.863	5.81	2.69	3 78
12.5	.314	.187	.257	.235	.156	.199	.678	.591	.621	2.15	3.16	2.41
17.5	.157	.125	.142	.104	.125	.113	.443	.435	422	2.82	3.48	2.97
22.5	.052	.125	.085	.052	.062	.056	.339	.310	.309	6.51	2.48	3.63
27.5	.052	.000	.028	.026	.000	.014	.287	.248	.253	5.51	—	9.03
32.5	.000	.000	.C00	.000	.093	.042	.261	.248	.239	—	—	—
37.5	.000	.187	.085	.052	.093	.056	.261	.155	.197	—	0.82	2.31
42.5	.105	.000	.057	.105	.031	.071	.209	.062	.141	1.99	—	2.47
47.5	.105	.062	.085	.078	.031	.056	.104	.031	.070	0.99	0.50	0.82
56.0	.052	.000	.028	.026	.000	.014	.026	.000	.014	0.5	—	0.50

(Contd.)

Table. 4.5 (*Contd.*)

(*b*)

1	*2*	*3*	*4*	*5*		*6*	*7*
4.5	1.00				$\therefore G=\frac{90.30}{3.16}=28.57$ Years	.810	.366
12.5	.60						
					estimated $R_m=0.04027$	.355	.160
17.5	.66	1.00	.66	11.55	$R_m=0.0424$	.317	.147
22.5	1.00	1.00	1.00	22.50	$=1.0434$	.389	.176
27.5	.00	1.66	0.00	—		—	—
32.5	.00	1.50	0.00			—	—
37.5	1.00	1.50	1.50	56.25		.207	.093
42.5	.00	1.00	0.00			—	—
47.5	1.00	—	—			.131	.059
			3.16	90.30		2.209	

(*iii*) Jalalpur Zora (G—071)

(*a*)

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
4.5	.238	.333	272	.238	.249	.242	.875	.927	.858	3.67	2.78	3.15
12.5	.238	.166	.212	.190	.083	.151	637	.678	.616	2.67	4.08	2.90
17.5	.142	.000	.090	.118	.083	.105	447	.495	.465	3.14	—	5.16
22.5	.095	.166	.121	.095	.124	.105	329	.412	.360	3.46	2.48	2.97
27.5	.095	.083	.090	.071	.041	.060	234	.288	.255	2 46	3 46	2.83
32.5	.047	.000	.030	.023	.041	.030	163	.247	.195	3.46	—	6.50
37.5	.000	.083	.030	.023	.083	.045	140	.206	.165	—	2.48	5.50
42.5	.047	.083	.060	.047	.041	.045	117	.123	.120	2.48	1.48	2.00
47.5	.047	.000	.030	.047	.041	.045	070	.082	.075	1.48	—	2.50
56.0	,047	.083	.060	.023	,041	.030	023	,041	.030	0.48	0.49	0.50

(b)

1	2	3	4	5	6	7
4.5	1.0	0.00	0.50	6.25	.740	.615
12 5	0.5	1.00	—	—	.235	.195
17.5	0.0	1.33	1.80	40.5	—	—
22.5	1.0	1.80	0.83	22.82	.258	.214
27.5	0.5	1.66	—	—	.095	.079
32.5	0.0	1.50	2.00	75.00	—	—
37.5	1.0	2.00			.105	.087
43.0	1.0				.075	.062
48.5	0.0				—	—
56.0	1.0				.034	.028
			5.13	144.57	1.202	

$$\therefore \; G=\frac{144.57}{5.13}=28.18 \text{ years}$$

estimated R_m=.058

observed R_m=.06

=1.062

(iv) Rampur/Niamatipur (G—130)

(a)

1	2	3	4	5	6	7	8	9	10	11	12	13
4.5	.304	.214	.270	.195	.214	.202	.833	.852	.861	2.74	3.98	3.18
12.5	.086	.214	.135	.129	.178	.148	.638	.638	.659	7.41	2.98	4.88
17.5	.172	.142	.162	.172	.142	.162	.509	.460	.511	2.95	3.23	3.15
22.5	.172	.142	.162	.102	.106	.108	.337	.318	.349	1.95	2.23	2.15
27.5	.043	.071	.054	.043	.035	.040	.235	.212	.241	5.46	0.33	4.46
32.5	.043	.000	.027	.043	.000	.027	.192	.177	.201	4.46	0.00	7.44
37.5	.043	.000	.027	.064	.071	.067	.149	.177	.174	3.46	0.00	6.44
42.5	.086	.142	.108	.043	.106	.067	.085	.141	.107	0.98	0.99	0.99
47.5	.000	.071	.027	.021	.035	.027	.042	.035	.040	0.00	0.49	1.48
56.0	.043	.000	.027	.021	.000	.013	.021	.000	.013	0.48	0.00	0.48

(Contd.)

Table 4.5 (*Contd.*)

(*b*)

1	2	3	4	5	6	7
4.5	1.0	1.25	1.25	15.62	.678	.574
12.5	1.0	1.80	1.18	20.79	.166	.315
17.5	0.6	1.25	1.25	28.12	.170	.140
22.5	1.0	2.00	0.10	2.75	.062	.143
27.5	0.5	2.00	—		—	.052
32.5	0.0	1.00	—		—	.075
37.5	0.0				—	—
43.0	1.0				.071	.060
48.5	0.5				.034	.028
			3.78	67.28	1.181	

$\therefore\ G = \dfrac{67.28}{3.78} = 17.76$

estimated $R_m = .0926$

Observed $R_m = .088$

$= 1.0920$

Ilaichipur (Y-045)

(*a*)

1	2	3	4	5	6	7	8	9	10	11	12	13
4.5	.380	.255	.330	.229	.185	.212	.698	.891	.827	1.83	3.49	.250
12.5	.079	.116	.094	.087	.116	.098	469	.706	.615	5.93	6.08	6.54
17.5	.095	.116	.103	.110	.116	.112	.382	.590	.017	4.02	5.08	5.01
22.5	.126	.116	.122	.078	.116	.094	.272	.474	.405	2.15	4.08	3.31
27.5	.031	.116	.066	.047	.104	.070	.194	.258	.311	6.25	3.08	4.71
32.5	.063	.093	.075	.063	.058	.061	.147	.254	.241	2.33	2.73	3.21
37.5	.063	.023	.047	.039	.034	.037	.087	.196	.180	1.33	8.52	3.82
42.5	.015	.046	.028	.022	.046	.032	.045	.132	.143	3.00	2.86	5.10
47.5	.030	.046	.037	.054	.052	.056	.023	.086	.111	0.76	1.86	3.00
	.079	.069	.075	.047	.034	.042	.069	.034	.055	.87	0.49	0.73
	.015	—	.009	.015	—	.009	.022	—	.013	1.46	—	1.44
	.15	—	.009	.001	—	.004	.007	—	.004	0.46	—	0.44

(*b*)

1	2	3	4	5	6	7
4.5	1.0				.761	.254
12.5	0.15	1.20	1.20	21.00	.202	.067
17.5	1.0	1.37	1.37	30.82	.385	.128
22.5	1.0	1.10	1.60	44.00	.293	.097
27.5	1.0	1.50	1.20	39.00	.223	.074
32.5	0.80	1.00	0.25	9.37	.135	.045
37.5	0.25	—			.032	.010
43.0	2.00				.180	.060
48.5	1.00				.709	.237
56.0	1.50				.070	.023
			5.62	144.19	2.990	

$$\therefore\ G = \frac{144.19}{5.62} = 25.65 \text{ years}$$

estimated $R_m = .0951$
observed $R_m = .055$
$= 1.0565$

(*i*) Laliana (H-037)
(*a*)

	2	3	4	5	6	7	8	9	10	11	12	13
	.136	.166	.147	.158	.083	.132	.922	.912	.919	6.77	5.49	6.25
	.180	.000	.117	.180	.083	.146	.764	.829	.787	4.24	0.00	6.72
	.180	.166	.176	.158	.208	.176	.584	.746	.641	3.24	6.69	3.64
	.136	.250	.176	.113	.125	.117	.426	.538	.465	3.13	2.15	2.64
	.090	.000	.058	.045	.041	.043	.313	.413	.348	3.47	0.00	6.00
	.000	.083	.029	.022	.083	.043	.268	.372	.305	0.00	4.48	10.51
	.045	.083	.058	.045	.124	.073	.246	.289	.262	5.46	3.48	4.51
	.045	.166	.088	.067	.124	.088	.201	.165	.189	4.46	0.99	2.14
	.009	.083	.088	.067	.041	.058	.134	.041	.101	1.48	0.49	1.14
	.045	.000	.029	.045	.000	.029	.067	—	.043	1.48	0.00	1.48
	.045	.000	.029	.022	.000	.014	.022	—	.014	0.48	0.00	0.48

(*Contd.*)

Table 4.5 (*Contd.*)

(*b*)

1	*2*	*3*	*4*	*5*		*6*	*7*
4.5	1	0.00	00.00	00.00		.706	.42
12.5	0	0.00	0.00	00.00		.000	.00
17.5	1	1.50	1 50	26.25	$\therefore\ G = \frac{129}{5.40} = 23.88$ years	.296	.17
22.5	1.5	1.66	2.40	54.00	estimated Rm=.0982	.369	.22
27.5	0 0	1.66	—	—	observed Rm=.071	—	—
32.5	1.0	1.50	1.50	48.75	=1.0721	.104	.06
37.5	1.0					.073	.04
43.0	2.0					.100	.06
48.5	0.5					.017	.01
			5.40	129.00		1.665	

APPENDIX D

Table 5.1 : Mono-(Primary) Population Pioneer Communities in the Khadar Tracts 1971+

Sl. No.	Code No.	Village	Total Population			Per Cent of			
			1951	1961	1971	Workers Population	Cultivators Workers	Labourers Workers	Primary Workers
1	2	3	4	5	6	7	8	9	10
A.	**Bangar Edge** (Truncated Series)								
1.	G—146	Nawada Khurd	245	304	382	36.66	87	13	100
2.	G—147	Pooth	437	565	642	31.46	59	41	100
3.	G—148	Kant Shakartila	141	160	213	36.15	100	—	100
B.	**Khola Zone** (Extended/Medium Series)								
4.	G—012	Jalalpur Raunakoli	—	—	15	33.33	60	40	100
5.	G—014	Mahammadpur Kheri		88	155	27.74	56	44	100
6.	G—098	Kiritpur	21	—	9	33.33	100	—	100
7.	G—144	Kutabpur	5	5	28	67.86	100	—	100
C.	**Trough Zone** (Extended/Medium Series)								
8.	G—126	Kothla	42	—	11	45.45	100	—	100

* Not present elsewhere
+ Based on Village and Town Directory, Distt. Meerut, 1971

(Contd.)

Table 5.1 (*Contd.*)

1	2	3	4	5	6	7	8	9	10
D.	**Valley Flat Central, (Extended Series)**								
9.	G—019	Haripur	58	81	97	30.92	90	10	100
10.	G—022	Ropra	—	4	2	50.00	100	—	100
11.	G—035	Kishanpur Khadar	245	63	70	20 00	79	21	100
12.	G—089	Mahmudabad	67	99	129	35 65	100	—	100
13.	G—093	Shahbad Garhi	—	9	8	50.00	100	—	100
14.	G—094	Sultanpur Dabal	21	—	64	29.68	100	—	100
15.	G—113	Abdullapur	125	140	181	27.62	94	6	100
E.	**Valley Flat, along Receding Meanders** (Extended/Medium Series)								
16.	G—021	Parsapur/ Hansapur	64	121	197	23.35	97	3	100
17.	G—077	Hadupura	31	8	190	31.57	82	18	100
18.	G—080	Aidalpur	42	—	91	42.85	100	—	100
19.	G—104	Bhagwanpur Khadar	3	—	8	75.00	100	—	100
20.	G—113	Mishripur	93	123	176	26.70	96	4	100
21.	G—120	Aidalpur/ Parshadipur	—	3	14	100.00	64	36	100
22.	G—143	Salahabad	—	—	3	33.33	100	—	100
F.	**Valley Flat, along Encroaching Meanders** (Extended/Medium Series)								
23.	G—039	Lalpur	126	186	3	33.33	100	—	100
24.	G—086	Kharkali	197	232	30	36.66	87	13	100
25.	G—088	Tarbiatpur Shumali	75	123	19	42.10	100	—	100
26.	G—121	Alampura Bhagwantpur	47	68	47	42.55	100	—	100

Table 5.2 : Truncated and Reminiscent Communities in Khadar Tracts, 1971+

Sl. No.	Code. No.	Village*	Total Population 1961	Total Population 1971	Workers Population	Per Cent of Primary Workers	Per Cent of Invading Workers	Per Cent of Link Wokers
1	2	3	4	5	6	7	8	9
A.	Bangar Edge							
1.	G—059	Ikwara	615	1,042	28.02	97	2	1
2.	G—072	Akbarpur Garhi	957	1,231	30.38	85	8	7
B.	Khola Zone							
3.	G—115	Khanpur/Makhanpur	4	4	100.00	75	—	25
C.	Trough Zone							
4.	G—011	Sarai Khadar	193	386	21.24	99	—	1
5.	G—032	Daulatpur/ Malipur	71	78	65.38	99	1	—
D.	Valley Flat, Central							
6.	G—017	Rithaura Kalan	369	327	21.71	99	1	—
7.	G—027	Nagli Khadar	239	383	27.67	92	6	2
E.	Valley Flat, along Receding Meanders							
8.	G—038	Shirjepur	618	677	30.87	97	2	1
9.	G—052	Bhadwa	263	447	27.74	94	3	3
F.	Valley Flat, along Encroaching Meanders							
10.	G—087	Khanpur Garhi	206	67	28.35	99	—	1
11.	G—121	Aldadpur/ Kolpur	67	67	31.34	95	5	—

* Not present elsewhere.
+ Based on Village and Town Directory, District Meerut, Census of India, 1971.

Table 5.3 : Inverted Communities in the Khadar Tracts, 1961+

Sl. No.	Code No.	Village	Total Population in Persons		Percentage of			
			1961	1971	Workers Population	Primary Workers	Invading Workers	Link Workers
1	2	3	4	5	6	7	8	9
Bangar Edge**								
1.	Y—003	Kuri (Rural)	4,252		65.30	45	15	40
2.	Y—010	Kotana	3,658		33.05	40	30	30
3.	Y—022	Sisana	2,857		43.57	43	42	15
4.	H—032	Amad Baghpat	691		40.81	50	28	22
5.	H—044	Alamgirpur Tukali	318		30.81	22	35	43
6.	H—065	Asalatpur/ Faruknagar	4,009		29.48	33	29	38
7.	H—069	Arthala	1,234		41.89	17	41	42
8.	*	Sadiqnagar	1,470		36.59	43	33	24
9.	*	Sihani	1,119		41.64	38	38	24
10.	*	Ghukna	441		51.92	11	70	19

* Partly included in Ghaziabad town
\+ Comparable data not available for 1971
** Not present elsewhere

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